ENGINEERING 21/6/57

ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 183 No. 4763 *LONDON, FRIDAY, JUNE* 21, 1957 PRICE 2s.

FITTING HEATING ELEMENTS FOR FURNACE

Nurnberg photograph for ENGINEERING

JUNE 21, 1957 VOL. 183 PAGES 769–800

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Vol. 183 No. 4763 June 21, 1957

Leading Article
Bread upon the Waters 769

Plain Words 770

Weekly Survey 774

Principal Articles
Modern Machinery in Horticulture: Power for Commercial and Domestic Growers 770
Engineering Firms in the Free Trade Area: 3—Index Werke K.G. 777
Research Centre for Australian Heavy Industry 779
Simulated-Flight Engine-Test Facility at N.G.T.E.: 1—Air, Power, Water and Fuel Supplies 780
Heater-Charger: Starting Engines from Cold 785
Measuring Small Displacements: Pneumatic Method for Observing Lift in Turbine Shafts 786
Torsional Waves in Wires: Disc Loading Increases Computer Memory 787
The French Aircraft Scene: 3—Engines 790
French Electric Locomotive Performance 792
Fuel Control Unit for Gas-Turbines 792
Stainless Steel Radiators 792
Screw Slotting Machine 793
Miniature Crucible Furnace 793
International Congress on Combustion Engines: 1—An Engine with Symmetrical Stressing 797
Bell Annealing Furnace 798

Letters to the Editor
Testing Steel Sheets 772
Management Training Courses 772
Training in the Use of Information 772
Fool-Proof Gear Changing 773
Brains in Series 773
"Hot Shift" Gearbox 773

Book Reviews
Induction and Dielectric Heating 788
Practical R.F. Heating for the Wood Industry 788
Mathematical Tables 788

New Books and Trade Publications 789

Notes
Centrifugal Sales Force 773
Queen's Honours List 775
New Engine for Vauxhall Velox and Cresta 778
Jaguar Factory Extension Completed 778
Report of the Technical Assistance Board 778
Choice of Three Radar Displays 785
Eye Strain and Infra-Red 785
400 kV Power Transformer 785
Scottish Television 792
Fire Alarm 792

Atomic Review
Chain Reaction 794

Marketing
Physicians to the Foundry Trade 776

Notices of Meetings 798

In Parliament 799

The Human Element 800

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Published every Friday by Engineering Limited, 35 & 36 Bedford Street, Strand, London, W.C.2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663.

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Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* (2*s.* 3*d.*)

BREAD UPON THE WATERS

AMONG the talents that have raised men from primitive and humble conditions to a life that is at least potentially civilised is the ability to record and communicate their experience. Such a talent might be expected to scatter its benefits throughout the world as fire spreads through a forest or rumour through a village, or as heat applied locally to a flask of water is soon communicated to the entire fluid. But, in fact, all countries are not equally prosperous. The reason is not hard to find: without an adequate supply of material resources man's latent skill and learning can amount to nothing; and inasmuch as these resources are not evenly distributed over the earth's surface, so some countries are rich and others poor. Once it was the possession of abundant water and fertile soil that brought riches; to-day it is the exploitation of electric power.

The World Power Conference has devoted its Eleventh Sectional Meeting in Belgrade to "Power as a Factor of Development of Underdeveloped Countries," and in so doing expressed its faith in the efficiency of communication. "Unless our experience can be of value to the underdeveloped countries," said a speaker from the West, "we have no purpose to be here at all." Yet many present considered it unprofitable to compare advanced countries with those only just embarking on industrial development. They argued that a young country could undertake a planned growth in the light of modern knowledge—thereby tacitly admitting that Western technical experience could be of value after all. The familiar correlation between energy consumption and national income was reaffirmed by many contributors, but it was shown that this could be no guide to investment in power plant, since the correlation was not linear and did not apply between countries at different stages of development, or even at the same stage. Thus although Norway and Denmark are almost equal in income per head, the energy consumption per inhabitant in Norway is some ten times that in Denmark. But this fact in itself is revealing: an underdeveloped country with, like Norway, vast hydro-electric resources, could well afford to establish a large power-consuming industry, engaged, for example, on metal recovery. The way to prosperity is to make the fullest and most effective use of the "dead capital" of unexploited indigenous resources, and there can be little doubt that by communicating their industrial experience to their poorer neighbours the advanced countries can assist in the process.

There are of course many snags. Resources remain unevenly distributed (but, as will be seen, the situation has to some extent improved in this respect). Owing to medical discoveries, population in some underdeveloped countries is growing at a catastrophic rate; in one part of the world it is said to be doubling every 35 years. Skill and technical understanding are at a low level in these countries. Rapid progress may mean a policy of frugality—sacrificing the present to the future—and this may only be possible in a politically disciplined or mature country. Major development, particularly in the field of power supply, can only be undertaken within a large framework, and this may mean Government control. The "lure of industrialisation" is blinding some nations to their true resources, though, of course, the desire of these countries to diversify their national product, to avoid putting all their eggs in one basket, is entirely understandable. But probably the most serious barrier to development is the shortage of capital, a problem that is much exacerbated by the investor's natural fear of nationalisation. This fear may to some extent be overcome by organising investment through governments or with government guarantees.

But in any case investment from outside will depend on the interest displayed by developed countries in the advance of backward countries. Will the sophisticated nations create manufacturing rivals for themselves, or lose their traditional sources of raw materials? The West will certainly remain masters of the subtler fields of technology for many years, perhaps centuries; and it is surely true to say that the more goods that are made, the more there will be to go round. (If everyone decided to make the same thing, however, there would be little advantage, but this tendency could surely be checked by sound investment policy.) The West, too, needs markets, and a country must be raised to a certain level before it becomes a significant market.

But ultimately, as Mr. Gunnar Myrdal has said, profitability cannot be the sole criterion. It is certain that the main effort must come from the poor countries themselves—they must "lift themselves by their own shoestrings," by internal saving and careful husbanding of their resources. What conditions favour their progress in the context of to-day? Resources are multiplying—materials unheard of yesterday are now in great demand; India, for example, has found new and rich surface deposits of thorium; the underdeveloped countries of the Middle East and Caribbean are the world's largest oil exporters. Nuclear power is not, like coal power, tied to the region in which the fuel is found (though the main immediate requirement of underdeveloped countries is for small cheap power sources—a need which nuclear

power cannot yet satisfy). Rivalry between the great powers may lead to a generous channelling of investment. As industrialisation proceeds there will be an increasing demand for the agricultural products of peasant countries. It is significant that even a rich country like Denmark can successfully base its economy on farming; indeed, if industrialisation is carried too far, food growing may again become the primary resource which determines the wealth of nations.

The most favourable condition, however, is the willingness of the West to pass on its accumulated wisdom. This may be just the impetus required for the backward countries of the world "to take off into sustained growth." Power must play an important, and probably a leading, part, for, as Sir Harold Hartley has said, "low-cost power is the key to prosperity." It is for the power-rich countries to give what help they can.

* * *

Plain Words

There is no more frustrating experience for anyone with technical knowledge than to have a perfectly sound proposal distorted and misrepresented by people who have more debating skill than technical ability.

It happens on the shop floor, in the design office, in the board room, and at meetings and conferences. If the subject under discussion is rather involved—if it can really only be understood after a certain amount of quiet study—keep your eye on the man who hasn't taken the trouble to brief himself but who has to take part in the discussion either because the final decision rests with him or because the department he represents is vitally concerned. He may be one of those dangerous types who have developed a flair for nudging others into agreeing to a decision which happens to suit them. He is likely to impute unworthy motives in those with whom he disagrees. He may keep quiet for most of the discussion and then come in with an observation which appears to be conclusive but which is actually dangerously misleading. If you are not ready immediately with your counter-argument you will probably never have the opportunity again. There are some men, endowed with exceptional intuition, who can reach the right decision with only a modest technical knowledge, but they are few and far between. Most engineering subjects to-day demand a readiness to get to grips with the technicalities.

But perhaps the most dangerous type is the man who, though he has technical knowledge, chooses to prostitute it by putting "political" considerations first. These people usually have the mental agility of a barrister and the charm of a self-made politician. You have to be very wide-awake indeed to take issue with them and get away with it. It is difficult to understand how men with a scientific background and education can forget the whole basis of their training. They breed resentment in others; but, above all, they are traitors to the scientific heritage to which we are all heirs.

MODERN MACHINERY IN HORTICULTURE

POWER FOR COMMERCIAL AND DOMESTIC GROWERS

By E. R. Hoare, B.SC., M.I.E.E.

There is a certain amount of rivalry between the Royal Agricultural Show (to be held at Norwich from July 2 to 5) and the Smithfield Show, as to which can be counted the national shop window for agricultural machinery. They both provide full displays, and at both a substantial number of the exhibits are for use in horticulture and in gardening. As horticulture is often run on highly intensive lines it lends itself to a reasonable degree of mechanisation. In this article, the author, who is head of the Horticultural Engineering Department of the National Institute of Agricultural Engineering, gives a picture of the present position.

The subject of horticulture brings to mind the domestic garden with its small lawn, herbaceous border and crazy paving; it is not so easily visualised as a dominant part of a major industry of the United Kingdom. The output of the horticultural industry in terms of food for human consumption is estimated at approximately £120 million annually, of which £53 million comes from vegetables grown out of doors, £33 million from orchard and soft fruit and £30 million is related to glasshouse and flower crops grown intensively. In addition, somewhere between £7 and £10 million of nursery material is sold annually to amateur gardeners, many of whom now invest in light machinery.

Horticultural crops in general represent one-fifth of our net agricultural production which, at £1,200 million, is still the largest single industry in the United Kingdom. General agriculture annually consumes some £90 million worth of machinery, of which horticulture certainly takes more than its proportionate share. So far as the external cultivations are concerned, on large vegetable growing the machinery requirements are very similar to general arable farming. Ploughing, cultivating, seeding and clean row-crop equipment occupies an important part, and it is the seeding and weeding equipment which has tended to influence the design of tractors and make them take the form of tool carriers rather than mere pulling devices. Special seeding units (Fig. 1) have been developed, which have been found to perform satisfactorily over a wide range of conditions. An examination of the patent files will show that many thousands of patents exist to improve seed drills, and yet it is fairly true to say that the majority of those on the market at the moment are still relatively simple and avoid needless complication. One reason for this is that the general biological uncertainty of reproducing a plant from seed, combined with climatic uncertainty, tends to produce a chance factor against which regular spacing of the seed is not as important as it might appear at first sight. It is only on specialised crops such as sugar beet that any satisfactory advance has been made.

Fig. 1 For agricultural machinery, simplicity of design, as in this seeding machine, is often more important than mechanical perfection.

Fig. 2 The modern agricultural tractor is increasingly becoming a tool carrier of great versatility.

With cultivating equipment development continues (Fig. 2) and is having considerable influence on the design of the tractor, in some cases giving rise to the tool carriage. The problem of this type of equipment is to combine hand accuracy with the characteristics of the machine. When hoeing weeds it is necessary to steer the equipment in such a way as to miss the plants; after several hours, fatigue dominates the accuracy of the process. Fatigue in turn is very highly dominated by comfort and hence the comfort of the driver is receiving attention, whilst keeping all-weather practicability in mind.

So far as harvesting processes are concerned there is still a lot of manual labour required; apart from pea viners there has been little

development. The brassica crops are harvested as simply as possible and are cut and graded in the field. The root crops which offer the greatest advantage to mechanisation are relatively easily damaged and, since payment often depends upon quality, it is frequently worthwhile to lift them by hand. Where trimming is required the harvesting of salad crops requires hand work, and this is just as easily done in the field as in the pack house. The advantage of washed prepacked articles, however, may alter this position and machines for field harvesting may have some economic advantage.

The washing machine is an important development in view of the spread of self-service shops. The importance has arisen from the need to show vegetables in plastics film containers enticingly displayed to the housewife. In developing this type of machine, the problem revolves around the amount of water to be used. A ton of roots may include several hundredweights of soil, which must be removed by the water and cannot easily be disposed into any normal sewerage system. The amount of water required per ton of vegetables would often be as high as 600 gallons, so the water should, if possible, be recirculated through the machine. This has resulted in various attempts at removing the sand and as many of the clay particles from the water as possible. For this purpose vibrating sieves of nylon mesh, through which the water is allowed

Fig. 3 The development of the air nozzle has enabled 10 gallons of spray to cover an acre, when formerly about 400 gallons were needed.

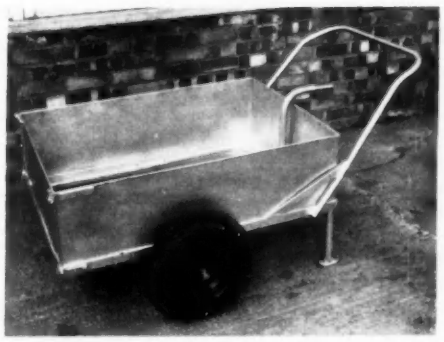

Fig. 4 (left) Improved crops can be obtained from sterilised soil. Soil for potting can be steam sterilised in a special wheel barrow.

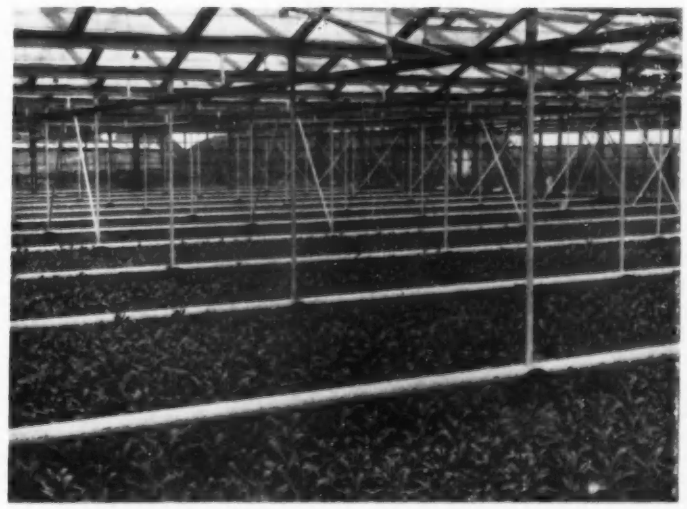

Fig. 5 (right) "Mobile" glasshouses — this one covers one-third of an acre of spring stocks— are being extensively used for flower crops.

to pass, have shown very good results. The vibration of the sieve allows small particles to be retained and they can then be delivered to one side. The filtered water is recirculated.

For fruit the machinery problems have been tackled in no uncertain manner, the gang mowing of grass and the specialised equipment for fruit tree spraying having received considerable attention. The general aim has been to spread films of toxic elements over the foliage and buds of the fruit tree in such a way as to keep the spores of fungi, or the eggs of insects, under proper control. Due to the development of very high toxicity often only a few pounds of material per acre is sufficient. Formerly it was usual to use some 300 to 500 gallons of water to spread this material evenly over an acre of fruit trees. With further development, however, the greater dispersal of fluid by means of air nozzles has enabled 10 gallons of fluid to do the work that previously required some 400 gallons. This has resulted in lighter machinery capable of covering a bigger area in a given time without the need for so much water (Fig. 3). The mechanical harvesting of fruit has not developed to any great extent because the selection and the disposition of the fruit on the tree does not render it easy for handling by machinery.

For the more specialised crops that are grown in glasshouses, the machinery aspect has become very important. The heating of the glasshouse has shown a rapid change, and small-bore high-speed hot water systems have replaced the large-bore low-velocity variety. Since these improved heating systems respond very much more quickly to variations in temperature, the methods of growing have altered. Tomato crops can be grown at constant night medium temperatures, and over 90 tons of tomatoes have been picked to the acre. Many commercial holdings exceed 65 tons to the acre and the national average is about 36 tons to the acre. These increased yields are only achieved, however, with high capitalisation on the boilers and heat distribution equipment together with the satisfactory steam sterilisation of the soil (Fig. 4). This capitalisation reaches nearly £20,000 an acre.

The use of the steam boiler feeding steam over a wide area of a nursery has led to special techniques for horticulture. The steam can be raised in the normal manner in package-type boilers and passed through mains at pressures ranging from 6 lb. per sq. in. to 120 lb. per sq. in. At the point of entry into the glasshouse the live steam can be injected into the water circulating system, which is kept in constant movement by means of circulating pumps. The normal method of control is for the temperature of the glasshouse to govern the ingress of steam. The firing of the boiler is controlled in the normal manner from pressure range switches. The particular problem of the horticultural boiler is that the yearly load factor rarely exceeds 0·25 and the maximum demand per acre is of the order of 3,000,000 B.Th.U. per hour per acre. Thermostats for use in glasshouses are not yet sufficiently developed since accuracy is required with relatively low inertia, and they should be capable of accurate setting from time to time without elaborate calibration. The control of ventilation of the glasshouse is also a subject which has not received proper investigation and most forced ventilation systems are inadequate. This arises from the high level of solar radiation, which results in air changes of the order of 120 an hour being required. The external and inlet velocity must be kept at a minimum and in consequence special duct systems become prohibitive in cost, and most fans too expensive to operate. It is thought that the adequate design of self-controlling ventilators using the thermal gradient will be the more profitable solution. Since the glasshouse industry has a running capital value of some £80 million, it is estimated that it is absorbing some £4 million a year on reinstatement.

It is particularly noticeable in the propagation stage that sterilised composts, soil block making machines and the tray handling of plants, have produced a standard commodity, which later ensures a more effectively guaranteed crop.

In raising large numbers of tomato plants considerable quantities of compost are required and compost mixing machines which eliminate the stones and break down the turf are in considerable demand. The use of granulated peat in connection with these composts has developed a specialised industry in both the West Country and Ireland. For adequate steaming of glasshouse soils it has been necessary to dig the soil and to insert the steaming pipes while digging is in progress. Equipment has now been developed, however, which will enable the soil to be rotary cultivated and for steaming ploughs to be pulled through the soil by means of slow moving winches

Fig. 6 (left) Horticultural adaptation of the ubiquitous electric drill includes hedge cutters and verge trimmers.

Fig. 7 (right) Hand digging can be effectively replaced by a rotary hoe, provided the machine has sufficient penetration.

at such a rate as will adequately sterilise the soil *in situ*.

If necessary, the whole of the watering can be arranged throughout a full season with complete automation. This process is based largely on the fact that the plant loses water in proportion to the solar energy falling on the green leaves, and in consequence, a measurement of the solar energy can operate a water inlet system so that the requisite quantity is supplied at the desired intervals. The use of plastics pipes makes this economical. Electrical storage systems, so far as automation is concerned, enable the water quantity to be integrated from the recording instruments and the water to flow to the crop at the correct times. Nutrition can also be added to the watering systems, and chemical analyses of the plants have indicated the correct quantities of chemicals to use. The resultant yield can be more certain.

So far as harvesting in the glasshouse is concerned, hand work is still required, but there are very many special machines used in grading the produce. An important aspect of these machines is that they should handle large quantities of produce without damage and not be too costly to purchase. For very specialised crops such as mushrooms, a crop which has now become worth over £7 million a year, special composting and transport equipment is used.

Flower growing has increased in size considerably, and with an output value of some £15 million a year, has shown considerable ingenuity in the use of mobile glasshouses (Fig. 5), and is tending to make great use of the Polythene and P.V.C. films. These films, unfortunately, while transmitting light, at the same time pass very long wavelengths and do not in consequence behave in the same manner as glass as they allow warmth to escape. The further development of satisfactory films with transmission characteristics similar to glass are eagerly awaited by the horticultural industry.

In the domestic market the extended use of machines by the general public has been equally noticeable; the continued application of the electric motor and small two- and four-stroke lightweight petrol engines to the lawn mower is an outstanding example. The hedge trimmer, the grass verge trimming equipment and apparatus for trimming grass banks has eliminated the odd job man. Many of these machines have been developed in conjunction with the hand electric drill and the handy man can now use his power equipment for trimming the hedge and cutting the grass verge (Fig. 6).

The problem of replacing hand digging in a garden has not been so easy of solution. The larger grower resorts to the use of the plough and the soil becomes completedly inverted; the small rotary hoe does not show the same horticultural advantage. Nonetheless the medium-sized rotary hoe working a width of some 14 in. or so can replace hand digging in the vegetable garden, especially if the garden is arranged to accommodate long rows of plants. In order to be satisfactory the equipment must be of a certain minimum weight to penetrate the soil and thus adequate digging equipment cannot also be lightweight equipment (Fig. 7). For after-cultivation very much lighter equipment can be used and small rotary hoes of many types are to be found on the market. Since a large number of power units would be an unnecessary waste so far as the domestic user is concerned, most have been arranged to combine cultivation, grass cutting, spraying and hedge cutting by the use of attachments.

Taking all in all, the improvement over the last ten years has not been so much in basic design as in the elimination of all needless components; as a result the price of such equipment has come within the reach of the domestic gardener. The psychological attitude of the present has moved towards this change and it can be argued that the advent of the washing machine into the kitchen has led indirectly to the introduction of the small cultivator into the garden.

The design of hand tools has received considerable attention as well, and since our enthusiastic gardeners are often women who have no wish to spoil their hands or develop heavy muscles, the designers have made such equipment as light and as useful as possible. Lawn shears, pruners, trowels, all show the result of considered design. A very conservative estimate puts the number of enthusiastic or not so enthusiastic gardeners as around 7 million, and it is very doubtful if the market possibilities have reached any degree of saturation. That we probably make each year some £4 million worth of lawn mowers and export nearly £2 million is one example.

In the larger sphere of commercial horticulture, steady development continues and the degree of mechanisation can perhaps be fully appreciated by pointing out that the net productivity in horticulture is probably as high as in any basic industry in the country.

Letters to the Editor

TESTING STEEL SHEETS

SIR, The article by Mr. I. M. Mackenzie and Dr. R. Kennedy on ultrasonic testing of heavy steel products (ENGINEERING, May 24, page 652) is a very valuable review of the subject. I found the paragraphs describing the detection of laminations and the inspection of metal-to-metal bonds particularly interesting. The authors refer to the difficulties of applying ultrasonics to thin plates. Cold-rolled sheet was not mentioned by the authors and it may be of interest to your readers to know that B.I.S.R.A. have developed a method of inspection for such flaws in these materials. The method, based on the measurement of electrical potential when direct current is passed into the sample, is simple and is suited to works application. Instruments based on these principles are now commercially available.

Yours faithfully,
B. O. SMITH.

Physics Department,
The British Iron and Steel Research Association,
140 Battersea Park-road,
London, S.W.11.
June 6, 1957.

★ ★ ★

MANAGEMENT TRAINING COURSES

SIR, In your article "The Road to the Top," on page 674 of your issue of May 31, you list a number of management training centres and courses in a phrase which gives the impression that those mentioned constitute the complete facilities in this field.

Sundridge Park Management Centre does in fact provide the capacity for a larger number of senior managers on courses than any of the excellent centres listed in the article. Five hundred executives have attended residential courses at Sundridge Park since February, 1956.

Yours truly,
J. V. CONNOLLY.

Sundridge Park Management Centre,
Bromley,
Kent.
June 7, 1957.

★ ★ ★

TRAINING IN THE USE OF INFORMATION

SIR, Referring to the letter by Mr. E. G. Baxter on page 679 of your issue of May 31, I agree entirely with the point made by him and would like to draw your attention to the work being done by the Institution of Production Engineers in this field. A sub-committee "Sources of Information," of which I have the honour to be chairman, has been formed and is responsible to the main research committee. The purpose of this sub-committee is to prepare a guide on sources of information for production engineers, in order to bring to their attention the great scope of practical information that can be made available by the correct use of the different sources available, from a simple use of the local public library to utilising the archives of different Government departments.

In carrying out this work, I have come across a great number of people who are of the opinion that it would be more than worth while to include in all professional examinations one subject in which the students had to give evidence of their ability to use sources of information. It has been argued that even if one took 10 per cent. off the available time for other subjects in the student syllabus, in order to provide time for training in the new subject, the fact that they would be able to delve out information easily

would more than adequately compensate, in the long run, for the cut in the other subjects.

Not only are advances in the sciences, technologies, administrative techniques, and so on, becoming more rapid of recent years, but even the number of studies is increasing. Consequently, no individual, whatever his sphere in life, can hope to be competent in all the different fields of activity that have some bearing on his own. In these circumstances, the need for that training, whereby an intelligent person can obtain rapidly the information which he needs to assimilate, is becoming of paramount importance.

Yours faithfully,
P. SPEAR,
Director of Research.

Rubery, Owen and Company, Limited,
Darlaston,
Wednesbury,
Staffordshire.
June 5, 1957.

★ ★ ★

FOOL-PROOF GEAR CHANGING

SIR, Referring to the article " Towing Troubles," published on page 701 in your interesting journal of May 31, it may not be generally appreciated that compound epicyclic gear trains in automobile transmissions should preferably be lubricated through both the input and output shafts, for, if either of these shafts stops running while the other remains in motion, a seizure could occur due to the lack of lubrication of some of the internal gears and their bearings.

In the Talbot semi-automatic transmission, which I designed in 1932, oil was supplied to the centre of the epicyclic gear trains in two ways—from the engine, and from the gearbox sump by another oil pump driven by the cardan shaft. Thus, a driver could descend an alpine pass with the engine stopped if he wished; the gearbox being immune from seizure and the brakes up to their task.

Another important safety factor in some transmissions of the two-pedal type is the need to ensure that, when a centrifugal clutch is used, and is disengaged while the engine is stopped or idling, the car, when in gear, is still subject to the retardation provided by the engine acting as a brake.

This was taken care of on the Talbot centrifugal clutch by a reverse free wheel which automatically engaged the engine the moment the latter's speed was overtaken by that of the car. By the same token, the engine could be started by pushing the car and could not stop while the vehicle was in motion and in gear.

Yours faithfully,
GEORGES ROESCH.

53, The Woodlands,
London, N.W.11.
June 13, 1957.

★ ★ ★

BRAINS IN SERIES

SIR, In your interesting leader, on page 737 of ENGINEERING for June 14, you quote your correspondent's central statement that we must " have the ultimate in view as clearly as possible . . . in whatever direction of engineering technology."

There is much evidence that engineers in most of the advanced industrial countries of the world are now giving thought to the ultimate of their efforts. It is realised that the human process of converting the supplies of nature into mechanism for human convenience and comfort is not enough. Man has been doing this on a scientific basis for the past 200 years, but the only result has been to provide means for increasing the speed of production and communication. The essential needs of man have not changed through the centuries: but, with our vastly greater knowledge of nature's laws, we have become lost in a mass of scientific and technical detail, and have overlooked the ultimate—the purpose of it all. We know quite definitely that one day our individual efforts must cease on this planet, and on reflection, we ask what is it all for and what is the ultimate.

Many engineers to-day seem to be dissatisfied with the idea of just increasing the efficient use of nature's gifts. They want the whole human community to understand what this great work means to life on this planet, so that all may work, as you say, in parallel. The ultimate goal must remain a matter of faith in the Great Architect of the Universe.

Yours faithfully,
JOHN D. TROUP.

48 Plough-lane,
Purley,
Surrey.
June 14, 1957.

★ ★ ★

" HOT SHIFT " GEARBOX

SIR, The caption to the illustration on page 730 of the issue of June 7—" Using this epicyclic gearbox, a vehicle need not be brought to rest before being put into reverse "—reminds me of a story told me before the first World War in which a Model T Ford car (which had the same reverse facilities) was involved:—" He reversed so quickly that the car started going backwards before it had stopped going forwards."

Yours sincerely,
HUGH CLAUSEN.

17 Harman-drive,
London, N.W.2.
June 7, 1957.

★ ★ ★

CENTRIFUGAL SALES FORCE

The pre-war saying " the customer is always right " seems to have gone by the board. But in the engineering world it never counted for much anyway, because the customer often has to be advised on a choice of design or process by the supplier. A firm which takes great pains to give such a service is Sharples Centrifuges, Limited, the British counterpart of the Sharples Corporation, Philadelphia, U.S.A. Last week their fine new offices and works at Doman-road Camberley, Surrey, were officially opened by Mr. J. J. Serrell, president of the Sharples Overseas Group.

When the British company was formed in 1923, Mr. P. T. Sharples, president of the Sharples Corporation, said " We shall produce and sell first quality products only; never offer for sale anything not, in our judgment, best for the purpose and a good bargain to the buyer; never make a deal that is not profitable to both parties." To-day, this kind of service can only be given by a firm which has the facilities and staff to do research and development work on behalf of the customer. These facilities are amply provided for in the new building, which is of modern design and has been planned to facilitate considerable expansion at a later date.

Within the factory area is a pilot plant, machine shop, laboratory and test bay linked with a glass-enclosed tower, designed to take special tanks used for development purposes. Whilst heavier production will still be done at the Lightpill Works, Stroud, full facilities are now available in the new works for machine testing, development, and modifications to standard machines. The service organisation is available to customers throughout the country, and is backed by a qualified staff in the sales and technical departments.

★ ★ ★

The Lord President of the Council has appointed Sir Harold Roxbee Cox and Dr. C. J. Smithells to be members of the Council for Scientific and Industrial Research.

Weekly Survey

Cover Picture: *The illustration shows the heating elements of a shaker-hearth continuous heat-treatment furnace being tested to ensure that they are a good fit in the firebrick support. This fitting is essential in order that the elements may be changed quickly while the furnace is hot.*

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Free Trade Area Undertones

Much play has been made in the last week or two with the delays in the Free Trade Area negotiations. There is nothing very new in these delays and they were referred to in a note in ENGINEERING of May 10, page 581. In the last few weeks nothing has done very much to change one way or the other the prospects for the Free Trade Area coming into existence. The recent remarks of Sir David Eccles and his visit to Rome last week in order to explain what may be misapprehensions about the British attitude are probably not more than ripples on the surface which would require a good deal of active stimulation to whip up into a storm. There may be those who would like to see the storm created and the Free Trade Area project jettisoned, but for the time being the scheme moves gradually if haltingly forward.

There are bound to be many cross currents in an international project of this kind. In all countries concerned there are influential groups who do not agree with the official view about the desirability or otherwise of establishing the Free Trade Area but broadly the position on the Continent is as follows. The French and Belgians are more impressed by the possibilities of the European Common Market, now established under the Treaty of Rome and awaiting parliamentary ratification than they are with the proposed Free Trade Area. They know that the E.C.M. offers them definite provision for " harmonisation " of wages and an agreed tariff reduction scheme. For them, the F.T.A. offers no more at present than a hope of such agreement. The French in particular would like more time to digest the E.C.M. arrangements so that to the British they appear to be dragging their feet. The Italians favour both the F.T.A. and the E.C.M. for they are happy to make a break with the past and they have reserves of both technical and unskilled manpower to mobilise for industrial expansion. The Dutch are favourably inclined to the F.T.A., for in many cases they probably have useful cost advantages over competitors.

The Germans (in theory probably in the strongest position of all Continental countries) are in favour of the Free Trade Area. To some extent they fear the unknown future which the F.T.A. may bring to them but northern German industrialists in particular, including powerful engineering interests, favour a closer economic link through the F.T.A. with Anglo-Saxon Britain and Scandinavia as a counterweight to the powerful Latin influences in the E.C.M. Scandinavia will probably come in because it cannot afford to stay out. There is indeed a good deal of making a virtue of necessity in many countries' attitude to the whole project. Everywhere there is as yet a woeful lack of factual data to work out the implications of the Free Trade Area on individual industries and companies.

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Standards and the Common Market

There is more behind standardisation than the mere ability to interchange parts. The whole question of purchase by guarantee is involved, in that the buyer has simply to give the number of the British Standard Specification to ensure that his purchase will fall within known

limits. British Standards have been used in the past as bases for contracts abroad and it is to be hoped—indeed it is probable—that this use will be extended with the introduction of the Common Market and the Free Trade Area. The significance of this facet was brought out at the recent Standards Officers' Conference held in London, by Mr. P. D. Canning of the Plessey Company.

The observations raised as a result of a discussion on international standardisation that was introduced by Mr. Gordon Weston, the technical director of the British Standards Institution, were that, with the growing competition between firms and countries, there will be a greater interchange of trade, and it will be all the more important for buyers in one country to know the substance of the purchases that they are making from another; this can only be done if the standards to which the items have been built are known. Some of the difficulties in the international co-ordination of standards are the differences in terminology that now exist in such spheres as acoustics, plastics, rubber, and nuclear energy. Another difficulty is the inch-metre problem; it would probably be necessary in some international standards to maintain both series of measurement.

Yet another point was raised at the conference in reference to screw threads. In spite of the recent drive for the adoption of the Unified screw thread, it was suggested by Mr. C. H. Gubbins, of Wolf Electric Tools, that it might be better in view of the European market, to adopt a metric system rather than the Unified thread. It was reported that at a recent international standards meeting in Lisbon, the Unified thread had been agreed for adoption in international standards as the only inch alternative to the metric series.

The role of the standards department in a factory might be regarded primarily as an information service. Where there were a number of factories scattered over a wide area, some possibly abroad, the standards department was useful in spreading information and keeping them in touch. The duty of a standards officer was said to be to obtain information, interpret it and present it complete to the designer. The advantages of standardisation of parts within a large firm were very great, both from economy and storage points of view.

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The Importance of Averages

A special number of *Productivity Measurement Review* for April, 1957, deals with the use made in French industry of inter-firm comparisons carried out in the United States and in France. This exercise, which owes a good deal to the inspiration of the United States Bureau of Labor Statistics, is part of the European Productivity Agency's effort to increase productivity through measurements and comparisons of productivity at plant level. This pamphlet is the latest attempt to improve the scope of inter-firm comparisons and to enable concerns to compare their own performance with the average. It is one more milestone, if a fairly modest one, in the long journey of persuading managements that they should use comparative productivity techniques and divulge information confidentially to allow the complex of averages to be assembled.

Although such organisations as the British Productivity Council and the British Institute of Management have done much hard work in the United Kingdom in this and closely allied fields there is still a general lack of interest on the subject. One or two industries have done systematic work on the subject, among which the boot and shoe industry is outstanding. There are a number of investigations being conducted into costs in different industries throughout Europe but they all suffer, when it comes to inter-European comparisons, from lack of standard terminology. This naturally reduces their usefulness but the need for systematic, co-ordinative work on this subject with the arrival of the European Common Market may be brought home quickly to industries on the Continent if not in this country.

Nevertheless, the case for making use of inter-firm comparisons in British industry grows daily stronger. Individual companies in engineering, for instance, may soon wish to know how their costs compare with European competitors in the Free Trade Area if it ever comes into existence. Little is known about how the average costs in British engineering compare with those on the Continent and even less is known of how widely dispersed individual companies are from the average.

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Plums Behind the Curtain?

An increase of United Kingdom exports to the U.S.S.R. to £40 million in 1957 was forecast last week by Mr. J. B. Scott, chairman of the Russian Section of the London Chamber of Commerce. This estimate, based on figures for the first four months of 1957, represents a rise of 40 per cent. on the 1956 total, and compares with direct exports of only £10 million in 1954. Mr. Scott was introducing a booklet on Anglo-Soviet Trade, designed to assist British firms interested in entering the Russian market or expanding their trade with the U.S.S.R.*

The London Chamber of Commerce considers the prospects for increasing Anglo-Soviet trade encouraging, but feels that there remain some anomalies in the stop list which could be removed. In spite of this, however, the booklet fairly draws attention to the drawbacks. Apart from the strategic embargo, which rules out many of the engineering products British companies could well supply, there are three principal snags, two deriving from the centrally planned Russian economy. The first is that it has always been Russian practice to use trade as a political weapon; with virtually all Russian foreign trade conducted by state corporations, it is more than ever important to distinguish between propaganda orders—or promises of orders—and genuine prospects. The second is that in Russian eyes, trade with the non-Communist world is to be regarded as marginal. It is deliberate Russian policy to reduce dependence on outside trade to a minimum. Finally, although the U.S.S.R. has gold reserves sufficient to finance an import surplus, she has difficulty in exporting sufficient of either raw materials or products to maintain a satisfactory trade balance.

In spite of these drawbacks, however, it is believed that sudden opportunities will continue to arise large enough to warrant the patient cultivation of contacts. Russia is stated to have a large demand for machinery and industrial equipment, in particular machine tools, electrical equipment, heavy industrial plant and power generating plant, and is also believed to have a continuing interest in imports of metals. A large part of the record 1956 imports from Britain was accounted for by £15 million worth of copper wire, while imports of British textile machinery amounted to over £2 million.

It is probable that in the foreseeable future, trade with Russia will not be of very great importance either as a bread and butter line to individual concerns or in relation to British trade as a whole. The occasional plums are nevertheless worth picking.

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A Second Owen Falls Dam?

Following the opening of the Owen Falls dam and the power station at Jinja in April, 1954, there has been a remarkable growth in the consumption of electricity in Uganda. In the first five months of 1957, 59 million kWh were generated compared with 37 million in the corresponding period of 1956. A large part of the increase was due to the starting up of the copper smelter at Jinja at the end of 1956, but even if this smelter and the new Nyanza Textiles factory are excluded, consumption by ordinary industrial, commercial and domestic consumers rose by 25 per cent.

The full capacity of the Owen Falls dam will be 150 MW, representing nearly 700 million kWh per annum at 50 per cent. load factor, a five-fold increase on present consumption. In view of the fact that a project of this size takes over five years to complete, the Uganda Electricity Board is already considering a second dam on the Nile and has commissioned the Economist Intelligence Unit to report on the likely economic growth of Uganda up to 1970, and to translate this assessment into terms of electricity requirements. Their report, "Power in Uganda," was published last week and confirms that the full capacity of Owen Falls is likely to be reached, if not by 1965, almost immediately afterwards. The report concludes that if these estimates are accepted, tenders for the work involved in constructing a new dam will have to be submitted in 1959.

Total electricity requirements within Uganda are estimated at between 456 and 504 million kWh by 1970, to which must be added a minimum offtake for Kenya of 309 million kWh, depending on the rate of development of consumption in that country and the output likely to be obtained from the proposed Seven Forks scheme on the Tana river. Of the consumption within Uganda, heavy industry (mainly the Jinja copper smelter, Nyanza Textiles, the cement industry, and the proposed fertiliser plant at Sukulu) is expected to account for 175 million kWh compared with only 11·7 million in 1956; light industry for 168 to 201 million kWh compared with 33·5 million; the domestic sector for 105 to 120 million kWh compared with 31·1 million and the commercial sector for 8 million kWh.

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More and Bigger Ships

The growth of shipbuilding throughout the world, and the widening gap between demand and supply, are striking features of the annual report of Lloyd's Register of Shipping. The past few years have not been of the happiest for British shipbuilders. They have had more than their share of labour troubles and difficulties in getting the materials they needed. They have lacked the type of confidence in the future which could have led to the quicker adoption of modern building methods. This is now changing, and the next few years should see British industry regain some of the ground lost recently to its Japanese and German rivals. Two annual reports of leading concerns, Cammell Laird and Company Limited and Harland and Wolff Limited, suggest that the present gap in the average building times between this country and others (18 months here compared with nine months in Japan) will be gradually reduced. This is important not only for British shipbuilding in its efforts to compete for world markets but quite vital to British shipping companies. Most of them have a large proportion of obsolescence in their fleets. The protracted deliveries quoted by most builders have greatly discouraged re-equipment, and, until recently, the high cost of new tonnage in relation to cash reserves has had a similar effect. The Chancellor's increase of the investment allowance for new ships has considerably improved the situation and there is more optimism in shipping circles than there has been for some time. Many now feel, as Mr. Walter C. Warwick, chairman of Royal Mail Lines, who have recently ordered three ships (costing £15 million) from Harland and Wolff. Expressing the hope that there will be industrial peace "with prospects of increased productivity throughout the country" he said his company

* Anglo-Soviet Trade: A Guide for Prospective Exporters and Importers. The London Chamber of Commerce (Russian Section) 5*s.* 0*d.*

were " reasonably justified in looking forward to another satisfactory year's trading." Yet there is something which the shipbuilding industry could do to help their customers, which the chairman of the Cunard Steamship Company called for in his annual statement. Saying it is impossible still to obtain fixed prices for new tonnage he said: " New construction to-day is an act of faith in the future; our faith would be greatly reinforced if we could have reasonable certainty of fixed prices and not be faced with ultimate first costs much in excess of those originally contemplated."

To a large extent, the inability to quote fixed prices is tied to the failure to reduce building times to a competitive level. The managing director of The Mitsubishi Shipbuilding and Engineering Company, Mr. Kaneo Niwa, considers that the extensive use of pre-fabrication and a harder working labour force are Japan's principal advantages. Mr. Niwa's optimisms concerning his industry's future is based upon rising world demand and Mitsubishi's ability to meet it quickly. Much will depend on the rate of growth which British builders can determine. Mr. J. C. Mather, chairman of Cammell Laird, described his own company's £17 million reconstruction scheme and expressed his confidence that, granted a greater measure of co-operation in stabilising conditions in the industry, " we can all look to the future with greater confidence." Sir Frederick Rebbeck, chairman of Harland and Wolff, indicated that large appropriations from profits to reserves were needed " to finance the purchase of new plant and machinery." Much remains to be done, and the quality of management in the industry badly needs improving. But at long last the industry is on the move.

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Profits, Prices and I.C.I.

The hopeful signs of a recovery in the level of industrial profits revealed by the *Financial Times*' lastest survey of industrial companies and the annual report of Imperial Chemical Industries are cheerful events in what threatened to become an arid period in British industry's growth. I.C.I.'s chairman, Sir Alexander Fleck, produced a review of industrial events and of factors affecting growth which could serve for the nation as a whole. Few companies in this country, or in the world, can be so broadly spread as to reflect the movements of the national economy.

Past performance, in 1956, was not unsatisfactory and is well in line with the experience of other large companies. Turnover increased to £435 millions (by just under six per cent.) but profits fell by a similar margin to £53½ millions. To some extent this is the result of a deliberate holding of prices and the reduction of some. This price-stabilisation policy will not now be continued indiscriminately, though fluctuations will be smoothed out wherever possible. Sir Alexander Fleck said that in future they would " consider each product on its merits, and adjust prices up or down as demanded by cost or market conditions." This should make for improved profitability and may set a pattern for the rest of industry. Taken in the context of Sir Alexander's broad picture of industrial activity, such a policy makes good sense. He foresees a continued expansion of industrial output over a long period, provided that British manufacturing industry takes steps to strengthen its competitive position in the world. I.C.I. can " look forward to a year of satisfactory progress " and regard the longer term prospects with confidence."

The qualifications for this are an alert product policy and aggressive selling overseas: " We indeed live in a dynamic world, and if we are to hold our place in it, it is essential that we seize every opportunity for growth and development." Sir Alexander Fleck's cheerful outlook and confident expectations echo the words of many chairmen so far this year. The next two to three years should be a period of unparalleled industrial growth.

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Half a Century of Rolls-Royce

A review of Rolls-Royce's position after 50 years and a tribute to his predecessor, Lord Hives, were the main features of Lord Kindersley's first annual statement as chairman of the company. Lord Hives's retirement marks what may prove to be the end of an era. He came to the company at the age of 22 as a tester when motor cars were their main and almost only product. During his 20 years as manager of the experimental department they made their first aero engine. When his chairmanship ended a few months ago the production of prime movers and power units had been extended to include a range of turbo-propeller and straight jet engines used by civil aircraft throughout the world, a popular range of oil engines for automotive industrial and marine duties and the germinating seeds of enterprise in nuclear engineering. A major research and development project for the application of nuclear power to drive a submarine is under way in co-operation with Vickers and Foster Wheeler. An agreement signed with North American Aviation Incorporated, who have progressed farthest in the development of rocket motors for guided weapons, should enable this country to keep to the forefront of this type of development. The purchase of Sentinel (Shrewsbury), Limited, primarily designed to provide suitable capacity for expansion, has brought the company into new fields—traditionally in the manufacture of rolling stock, and, by association with Renault, into the design and manufacture of components and equipment for automatic machine tool control.

The development of the company is thus clear in its broad outlines: so far it has been the story of providing prime movers for vehicles, which doubtless sprang from the excellence and world fame of the Rolls-Royce motor car. The characteristic of the development has been technical leadership, except possibly in oil engines where the best modern practice was followed. To-day, Rolls-Royce have a turnover of £80 million, and orders amounting to some £100 million. Cars are unlikely to account for more than one-eighth of this, although more were produced in 1956 than ever before. Lord Kindersley states that over half—£45 million—of last year's output was sold to the British Government. What he describes as commercial sales included a great deal of business with Commonwealth and foreign governments. For the time being the company remains primarily a supplier of war stores and can still be described as an " armament share." But the balance is changing, and will change at an increasing rate. As Lord Kindersley said, the anticipated decline in Britain's and the world's purchase of military aircraft makes the company dependent for their future turnover " on obtaining a larger share of the world market for engines and transport aircraft," in competition with United States manufacturers who have the advantage of very large domestic orders.

The future of Rolls-Royce remains firmly anchored to their past achievements in the development and production of aero-engines. Oil engines are as yet a small proportion of the company's output, employing probably less than 3 per cent. of their 42,000 workers. The next decade should see advances in rolling stock, ship and industrial power units as well as in engines for air transport.

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In their effort to break into the American car market, the Fiat Motor Company have converted two ships for the sole purpose of carrying cars from Italy to America. Each ship will be capable of carrying 1,000 cars on one loading.

THE QUEEN'S HONOURS

In all, some 2,600 names are included in the complete list of Birthday Honours announced on June 13, the first list since Mr. Harold Macmillan became Prime Minister. This total is about 600 more than that in the New Year Honours list of last January, but there appears to be relatively little change in the number of distinctions conferred upon engineers, scientists and industrialists, other, perhaps, than those in the Services and in the various Government departments.

Mr. Frederick Pickworth, chairman of the English Steel Corporation, Limited; Mr. William Sinclair, C.B.E., a director of the Dunlop Rubber Company (Scotland) Limited; and Mr. Edward W. Thompson, J.P., chairman of John Thompson, Limited, Wolverhampton, are created Knights Bachelor. Mr. Sinclair's honour is recorded as being awarded for his political services in Scotland. Others among the 36 new knights are Mr. Charles J. Geddes, C.B.E., a member of the General Council of the Trades Union Congress; Mr. Herbert G. McDavid, C.B.E., chairman and managing director of the Glen Line Limited; Mr. Alec T. S. Zealley, chairman of Remploy Limited; and Professor John L. Martin, Professor of Architecture at the University of Cambridge, who was architect to the London County Council for a number of years.

The honour of Knight Commander of the Order of the British Empire has been conferred on Brigadier Lionel H. Harris, C.B.E., Engineer-in-Chief, General Post Office; and on Mr. Leslie H. Robinson, C.B., Second Secretary to the Board of Trade. Mr. John H. B. Chapman, Principal Deputy Director of Naval Construction to the Admiralty, has been created a Companion of the Order of the Bath; and, among a number of distinctions conferred upon persons overseas, Mr. Roland S. Andrews, chairman and managing director of the Gas and Fuel Corporation, Victoria, Australia, has been made a Companion of the Order of St. Michael and St. George.

Commanderships of the Order of the British Empire have been conferred upon Mr. Charles K. Bird, general manager, Eastern Region, British Railways; Mr. Arthur T. Black, director of electronic production (munitions), Ministry of Supply; Mr. James W. Campbell, financial adviser to the Iron and Steel Holding and Realisation Agency; Mr. Norman R. Elliott, O.B.E., chairman, South Eastern Electricity Board; Group Captain Edward Fennessy, O.B.E., managing director, Decca Radar, Limited; Professor Edmund L. Hirst, Forbes Professor of Organic Chemistry, University of Edinburgh; Professor John L. M. Morrison, Professor of Mechanical Engineering, University of Bristol; Mr. James G. Pearce, O.B.E., director of research, British Cast Iron Research Association; Mr. Edward Player, managing director, Birmid Industries Limited; Mr. Douglas G. Sopwith, Director of Mechanical Engineering Research, D.S.I.R.; Mr. James Walker, chairman, Electricity Board for Northern Ireland; and Mr. Joseph Wright, O.B.E., director, Dunlop Rubber Company, Limited.

Among those on whom Officership of the Order of the British Empire has been conferred may be mentioned Mr. David F. Milne, generation engineer, Trummel Valley Stations, North of Scotland Hydro-Electric Board; Mr. George Morrison, managing director, Greenock Dockyard Company, Limited; Lieut.-Colonel Augustus C. Newman, V.C., director, W. and C. French, Limited, civil engineering contractors, Essex; Mr. Michael J. Ronayne, chief engineer, Ford Motor Company, Limited; Mr. Gordon Weston, technical director, British Standards Institution; Mr. Edward Whitworth, deputy research manager, Nobel Division, Imperial Chemical Industries Limited, Ardeer; and Mr. Arthur Wragg, chief metallurgist, Vickers-Armstrongs (Engineers) Limited, Newcastle-upon-Tyne.

Marketing

PHYSICIANS TO THE FOUNDRY TRADE

A good example of rapid growth through the energetic sales promotion of an effective technique is provided by Foundry Services Limited, who supply the foundry trade with fluxes and other casting aids. Some 25 years ago, two young engineers, Mr. Eric Weiss and Dr. K. Strauss, came to this country from the Continent to develop a project "embodying technical research with the production of special chemical and metallurgical preparations," which could serve foundries working in every class of metal. The company they founded, now known as Foseco, has become an international organisation with associated manufacturing companies in Canada, the United States, the Union of South Africa, Japan and four European countries.

The acquisition of a 60 per cent. holding in Foundry Services last autumn by Mineral Separation Limited will provide resources for research, development and sales promotion on the scale required by what has now become a world-wide manufacturing organisation. At a recent Press conference held to provide information on a 50,000 mile overseas tour by the company's sales director, Mr. R. A. Miller, the company clearly stated their intention to forge further ahead overseas. The main purpose of Mr. Miller's visits was "(i) to investigate the possibilities of increasing our exports and opening up new markets; (ii) to investigate and prepare for the establishment of our own companies particularly in India and Australia, for manufacturing, selling and servicing 'Foseco' products, and (iii) to ensure that our existing companies, such as those in Japan and South Africa, will develop as actively as possible." This is the kind of outlook and dynamic approach to the problems of marketing which promotes exports.

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Unconventional Conventions

Large gatherings of sales representatives are not a very popular method of improving the effectiveness of a sales force—in this country probably less than in Germany or in the United States. Yet more conventions are being held, and they are becoming occasions for very hard work indeed. In the early days of sales conventions a company's representatives would gather from all over the United Kingdom to have a wonderful time as only salesmen know how. Business was very secondary and introduced very gingerly if at all. The next stage of the convention's development was to make it the occasion for a number of pep talks from the sales manager and top management, followed by the usual festivities.

Modern methods are different. A well-run sales convention is a means of evolving sales policy, and a vital platform for the exchange of views on methods. They have become hard-working occasions, and above all they provide an opportunity for the field staff of a sales force to become acquainted with the company's development programme and to take part in planning its execution. The two sales conventions mentioned below are typical of to-day's purpose and methods. Both are world-wide and both are a means of getting together, under one roof, representatives and agents on whose efforts the companies depend for expansion.

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Ruston and Frigidaire

The international sales congress held by Ruston and Hornsby was essentially a get-together coinciding with the company's centenary year. Its success was not confined to "emphasising the remarkable family spirit which has characterised the relationship between the firm and its associates." The visit to the works and to the firm's new research centre helped to give those whose task it is to sell a range of products an up-to-date picture of the type of backing they can expect. They were told of the steps taken to maintain technical progress, and also of the company's difficulties in world trade. Mr. Harold Riggall, managing director, referred to "international political and financial upheavals" in the world outside a company's control which plague the British exporter.

Ruston's convention was thus largely an effort at public relations, putting the firm over to their sales staff and associates. Frigidaire, who are holding a full-scale convention to be attended by representatives from all over the world next January, are doing so to discuss their "five point development programme for commercial refrigeration." Some radical departures from past practice are to be introduced, such as, the granting of a five-year warranty on commercial air-compressor units, and price reductions ranging from 45 to 5 per cent. on some items. The sales convention six months after the launching of the new policy, will discuss its impact on the markets and thus provide a useful check on the management's judgment and estimates.

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Changing Pattern of Demand

Evidence continues to come in suggesting that the seasonal trade in cars is a thing of the past. The United States Market, for the second year in succession, has provided "no marked spring upturn in new car sales." Both the Presidents of General Motors and Ford, Harlow H. Curtice and Henry Ford II, have talked recently of the possibility that a far reaching change is taking place in the pattern of car sales. Both recognise that it has implications of the greatest importance to the industry.

Henry Ford discussed the new situation at some length in his annual report to shareholders "If a new pattern is developing which would distribute sales more evenly throughout the year," he said, "it might alleviate some of our scheduling problems and bring a greater degree of employment to the industry." This would not only make the industry's employment problems manageable but it could radically alter the manufacturing and selling costs. More regular demand would affect production schedules throughout the industry's suppliers and permit major economies. As Mr. Ford pointed out, to provide the extra capacity to cater for the traditional spring boom is a costly business for which the motorist has to pay.

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Air Freight to the Fore

The progress of United Kingdom air-freight services in the past two years or so has been a remarkable feature of world trade. Air freight, apart from passengers' luggage, has increased from just below 60,000 tons in 1955 to nearly 71,000 tons last year. Exports which went by air totalled 41,000 tons and account for 2·9 per cent. of total exports. The corresponding proportion for imports was 1·6 per cent. One of the private operators, Hunting-Clan Air Transport, who were granted a licence to operate a scheduled freight service to Africa, report that the amount of light engineering machinery and equipment has increased four-fold in the past 18 months. The company undertook a survey and concluded that there was "a growing acceptance of air-cargo services as a routine method of getting supplies delivered promptly and punctually to overseas engineering projects or depots."

This was by no means apparent two to three years ago, when several private operators investigated the possibilities of traffic on the main trade routes. Hunting's remark that many engineering firms who use their service regularly initially use it "primarily as an emergency measure" suggests that air shipments are found highly convenient by shipping departments. Wherever the value per lb. of the equipment justifies the extra cost there is little doubt that air freight is worth trying. Moreover, some economies can be effected—in packing costs, insurance rates, reduced incidence of damage, deterioration or pilferage. But the main advantage to the user—the firm wanting the machine or spare part—is improved service and less need to purchase large quantities of "safety spares" with each new item of plant.

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Poznan Returns

Poland is a favourite hunting ground of the British firms with serious designs on the eastern European markets. More than ever now, the Polish market itself presents opportunities. The considerable improvement in the political atmosphere has been matched by an improvement in the receptiveness of eastern European buyers to British products and there are good prospects of doing substantial business at the Poznan Trade Fair.

Three engineering companies—Associated Commercial Vehicles, Pye and Kelvin Hughes—have taken large stands. A.C.V. are taking one of their largest and latest vehicles, the 13 ft. wheelbase Mammoth and 21 ton trailer, laden with static engine exhibits, driving across Europe. Kelvin Hughes are displaying a very wide range of instruments including their echo-sounding equipment, recorders and projection equipment. Pye have taken 2,000 sq. ft. of floor space at the exhibition. Fresh from their success at Leipzig they are making a most determined attempt on markets which, in due course, may well provide a major export outlet for British engineering firms.

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Separation of Function

The experience of Monsanto Chemicals in the United States suggests that a company specialising in the production of industrial products—whether chemicals or machines—are not ideally fitted to sell goods to the public. The industrial market is one thing, the mass consumer goods market quite another. After the war Monsanto decided to market a range of chemicals widely used by the public, such as soap, detergents, soil conditioners (Krilium), water softeners, insecticides and herbicides. They have now reversed this policy and have made an agreement with Lever Brothers to market their very successful low-sud detergent.

The reasons for Monsanto's decision may go deeper than mere inability to master mass market techniques. Competition with their principal customers, for example, would lead to a loss of major business. But the sales techniques acquired are formidable enough, and foreign enough to an industrial enterprise, to explain Monsanto's changed policy. A short report published by the European Productivity Agency of O.E.E.C., *Soap, Detergents, Paint, Varnishes—Marketing Techniques in the United States*, provides an excellent introduction to a fascinating subject. Their principal conclusion, that "manufacturers must not consider distribution as secondary to production if they want to prosper under present-day conditions" is strongly supported. So is the contention that, in this field (as in most) "the importance of distribution has assumed such proportions that it is now the practice to invest in marketing as in production equipment, and to apply like calculations on such matters as depreciation."

ENGINEERING FIRMS IN THE FREE TRADE AREA

3—INDEX WERKE K.G.

Germany has probably less reason to fear the possible advent of the European Common Market and Free Trade Area than any other country concerned. She has little to lose by coming in to the union, since she already relies only to a very limited extent on import duties for protection of her home market. Her export prices in a wide variety of goods compete effectively in overseas markets, and her favourable balance of trade is reflected in the strength of the Deutschmark, whose remarkable recovery after the war was one of the most notable aspects of post-war monetary history. Already well experienced in one smaller customs union, the European Coal and Steel Community, of which she must be considered the leading member, Germany looks forward to the larger union with confidence.

Germany is the leading producer of machine tools in Europe, and Table I shows output and exports over the period 1953 to 1956. Total production in 1956 was valued at DM 1,632 million (equivalent to £140 million at the current rate of exchange), of which just over 40 per cent. was exported. The value of output has increased by approximately 60 per cent. since 1953 but although total exports have increased, the export percentage has fallen from 54 per cent. in 1953 to 40·9 per cent. in 1956. For comparison, the value of the deliveries of machine tools by British manufacturers was £85·3 million in 1956, of which deliveries for export accounted for 25 per cent.

TABLE I.—*Germany: Machine Tool Production and Exports, 1953 to 1956 (Value: DM 000.)*

—	1953	1954	1955	1956
Cutting Machine Tools				
Production ..	756,786	753,765	939,755	1,170,439
Exports ..	414,485	362,803	377,571	474,881
Non-cutting Machine Tools				
Production ..	261,435	278,510	402,196	462,050
Exports ..	136,428	160,072	177,385	193,778
Total				
Production ..	1,018,221	1,032,275	1,341,951	1,632,489
Export ..	550,913	522,875	554,956	668,659
Export per cent. ..	54·0	50·7	41·4	40·9

Index Werke K.G. of Esslingen are an important unit in the German machine-tool industry. Production of single-spindle automatic turret-type lathes, for which this company is noted, is a highly specialised field with few important competitors and the Index machine has an outstanding reputation for quality. Confidence in their future is given point by the fact that the order book which is growing steadily, continues to do so although their prices are considerably higher than those of their British competitors. Nevertheless the United Kingdom is the company's largest single customer. It is understandable that the prospect of a Free Trade Area causes little anxiety at Esslingen, and the only doubt which really troubles the company is whether its capacity can be expanded to match the future demands likely to be made upon it.

QUALITY FIRST

To maintain their reputation for craftsmanship, Index are not prepared to expand production at the expense of a possible reduction in quality. The present output is around 100 to 120 machines a month, amounting in value to about £500,000, and has shown little change over the last few years. There is a controlled production system manned by a team of craftsmen nearly all of whom have had three years' training in the apprentice school provided by the company and an additional year on the shop floor. Throughout this period an active interest in craftsmanship is carefully fostered and Index believe, as do many British companies which operate their own apprentice training schemes, that the standard of craftsmanship achieved is far above that implied by the term "skilled labour." The importance which Index attach to this conception can be seen from the fact that there are at any one time between 100 and 120 apprentices to maintain the present labour force of about 1,200. The company has followed this policy since it was formed at the end of 1913 by Herr Hermann Hahn, who had also founded some years earlier the tool and machine-tool manufacturing company of Hahn und Kolb A.G.

At the end of the war the entire capital equipment, stock and work in progress of the Esslingen works were offered by the British Government for sale to the highest bidder in the British machine-tool industry. The undertaking was purchased by B.S.A. Tools Limited, who shipped much of the plant and machinery to Redditch but later transferred it to Cardiff where they undertook production of Index machines. The German company built a virtually new plant at Esslingen and an agreement was made with B.S.A. Tools under which Index undertook the sale of B.S.A. machines in Germany and vice versa. The agreement was terminated in November, 1956, and George Kingsbury and Company, Limited, were appointed selling agents for German-built Index machines in this country.

Production processes at the Esslingen factory are designed to ensure the high quality of the product even when this results in relatively high production costs. All production is by the batch, every detail is hand-fitted and all parts machined in their own shops. Each part is then inspected and tested, and basically painted before being primarily assembled. The completed lathes are stripped down and the components again inspected, after which they are re-painted. Each machine is then re-assembled and given a six-day run during which further adjustments are made. The lathes are then again stripped down and all working components undergo another severe inspection. The machine is then reassembled, following which all final adjustments are made by the inspection department. After this extremely thorough process the turret bores are bored and lapped for the spindle in order to guarantee perfect alignment. The complete machine is then ready for delivery. Index claim the secret of their success lies in the method of heat treatment employed and the extreme rigidity of inspection which virtually ensures that no sub-standard component passes through to the final product.

CHIEF COMPETITORS

Besides holding a pre-eminent position in Germany, Index are strongly placed in export markets where their principal competitors are perhaps Brown and Sharpe of the United States. It would appear that the advent of a Free Trade Area within Europe will consolidate their position still further since any price advantage Brown and Sharpe may now possess would probably be eliminated if import duties on German products were removed and those on United States machines retained at their present level. Within Europe their main troubles are concerned with delivery. B.S.A. Tools Limited, who are the principal manufacturers of automatic lathes in the United Kingdom, are offering a number of machines ex-stock, while Index's delivery dates in this country range from 3 to 9 months. Moreover, this is achieved only by giving preferential treatment to export markets at the expense of their German customers. This is, of course, a policy followed by a number of German manufacturers, but it may be doubted how long it can continue in relation to capital goods. In effect, differential export delivery dates must result in some starvation of the capital equipment market within Germany, and in the long run this may be reflected in a weakening of the competitive strength of German industry as a whole.

Within Europe there are two other important competitors apart from B.S.A. These are Tarex S.A. of Geneva and Manufacture de Machins du Haut Rhin (Manurin) of Mulhouse. There are also a number of companies producing automatic bush turners which are not, however, truly competitive with turret type lathes although there may well be an increased demand for them if deliveries of turret type automatics become further extended. The extent to which Index's position is likely to be strengthened in a Free Trade Area is shown by an examination of the import duties imposed by European countries on automatic lathes. These are shown in Table II.

TABLE II.—*Import Duties on Automatic Lathes into Various European Countries.*

Country	Duty
Austria	Approximately £28 per 1,000 kg.
Belgium	6 per cent. + transmission tax of 8 per cent. on duty-paid value.
Denmark ..	5 per cent.
France	20 per cent. on automatic lathes of 3,000 kg. or less.
Germany ..	Duty free plus 6 per cent. turnover tax.
Holland	6 per cent. + one-ninth turnover tax on duty-paid value.
Italy	18 per cent. + 12 per cent. GATT rate + 4 per cent. compensation and 3 per cent. turnover tax on landed value + ¼ per cent. admin. fee on c.i.f. value.
Luxembourg ..	6 per cent. + 2 per cent. of duty-paid value.
Norway	15 per cent.
Sweden	10 per cent.
Switzerland ..	Swiss francs 20 on tools of 5,000 to 2,500 kg. + 5·4 per cent. of wholesale price when imported by wholesaler or retailer or Swiss francs 90 when imported by other means.
Spain	149·69 gold pesetas per 100 kg. + 20 per cent.
United Kingdom	17½ per cent.

HIGH-DUTY COUNTRIES

It can be seen that imports of machine tools into Germany are virtually duty free, and Index will not therefore experience any intensification of competition in their home market. As regards the machine-tool industry generally, Germany stands to lose nothing and gain a great deal with the advent of European free trade. What of her competitors? Probably the worst placed are the French with their 20 per cent. duty on imported automatic lathes. Only in 1956 did the French Government become fully aware of the needs of their expanding industry and the Ministry of Industry and Commerce is currently undertaking a comprehensive survey of the French machine-tool industry. This arose out of the inability of the industry to meet the current rate of economic expansion and the need to find ways and means to meet foreign competition in view of the prospect of increasingly liberalised trade. The interesting point emerged that the average age of machine tools in French industry is between 15 and 20 years. The replacement demand is obviously potentially high but the competitive position of the French machine-tool industry is hampered by high labour costs, high social charges and the high cost of raw materials, all of which lead to high prices. Skilled labour is also very short in an agricultural country, although the situation of Manufacture de Machins du Haut Rhin, close to Germany and Switzerland, may, given sufficiently attractive wages, enable them to attract labour from these countries. Be that as it may, they must be finding it hard to compete with German and British manufacturers even in France and will find it still harder in the future when they are no longer protected by a high tariff. The French machine-tool industry in general must look

upon the coming free market with mixed feelings but, since the demand for automatics is likely to increase, Manurin can possibly look forward to prosperous markets for some time to come in view of the limited capacity of their competitors. Whether this will continue in the longer term is open to some doubt.

What of Tarex of Geneva? It is still uncertain whether Switzerland will join the Free Trade Area, though many Swiss manufacturers think she may be forced to do so if she is to maintain her important export trade to European countries. If she joins, Tarex with its name for Swiss-type precision stands as good a chance as any automatic-lathe manufacturer and might be a force to be reckoned with by Index in France and in England, particularly considering the German company's strained capacity.

The most important manufacturer of turret lathes in this country is B.S.A. Tools Limited who at the moment are relatively well placed owing to their ability to offer quick deliveries ranging from ex-stock (for most sizes) up to about nine months. Their prices are also competitive and are likely to remain so even if the 17½ per cent. duty on German imports is removed. The advent of the Free Trade Area must be to their disadvantage in the home market, though they may find compensating advantages elsewhere. Quick delivery and competitive prices may provide a basis for success, and the United Kingdom machine-tool industry must gear itself to a competitive market with this in view.

INABILITY TO EXPAND

One of the long-term effects of the setting up of a Free Trade Area may well be the concentration of production throughout Europe into relatively large scale units. This, coupled with the degree of standardisation which it should be possible to achieve, may well result in a marked increase in demand for automatic lathes, and, in view of the difficulty of expanding German production in this field, there may be opportunitities for expansion by British manufacturers. The figures given in Table III, however, which show United Kingdom imports and exports of automatic lathes, reveal a disturbing inability in the United Kingdom industry to take full advantage of the expanding home market.

TABLE III.—*United Kingdom Exports and Imports of Automatic Lathes*, 1954 to 1956 (£1,000).

Year	Exports	Imports	Export (+) or Import (−) trade balance
1954 ..	1,508	1,258	+ 250
1955 ..	1,510	2,096	− 586
1956 ..	1,921	2,794	− 873

The figures suggest that the import totals might be considerably higher if British import duties were reduced. At the moment the United Kingdom import duty is far in excess of those in Germany, the Benelux countries and Switzerland. The only country which has a higher import duty and is of any importance in the machine-tool industry is of course France, but their 20 per cent. is very little in excess of the British duty. Since, in general, prices quoted by British manufacturers are competitive, particularly with those of the French, German and Swiss manufacturers, the rise in imports would suggest that many users of automatic lathes would prefer to pay a higher price for a better quality machine or one likely to have a longer life. To build up the type of labour force necessary to obtain the highest quality takes time and is hampered by the prevailing shortage of skilled labour in this country. The machine-tool industry has, however, not been particularly successful in expanding its skilled labour force, largely because it has felt unable to pay the high level of wages prevailing, for example, in the motor industry. The experience of Index would seem to suggest that this is a mistaken view and that the industry could well afford to raise prices, provided the increase is accompanied by a corresponding increase in quality.

British machine-tool manufacturers have achieved a considerable measure of success in exporting to the United States market over the last few years, but although this applies less to makers of automatic lathes than to other machine-tool manufacturers, the British industry has been much less successful than the German in European markets. Of total British exports of machine tools in 1956, 29·3 per cent. went to other European countries but over 46 per cent. went to the Sterling Area and Canada. By contrast, 64 per cent. of German exports went to European countries. Details of exports of automatic lathes by countries are not available for years later than 1955, but in both 1954 and 1955 nearly 70 per cent. of total British exports went to foreign as opposed to Commonwealth countries. In 1955 the most important markets were France (£260,000), Western Germany (£212,000), Italy (£125,000) and Sweden (£75,000).

In 1955, the most important sources of imports of automatic lathes into the United Kingdom were the United States (£915,000), Switzerland (£518,000), Western Germany (£384,000) and France (£195,000). Imports into the United Kingdom from Western Germany were thus not quite double British exports to that country and the disparity may be expected to increase if British import duties are progressively reduced. Nevertheless increased imports from Germany may to some extent occur at the expense of those from the United States and, in view of the anticipated increase in the total European demand for automatic lathes and the limited productive capacity available, the outlook for the British industry is by no means unfavourable. Greater freedom of competition will, however, place a premium on technical development, a fact of which German machine-tool makers are well aware. Index, for example, have three modernised drawing offices all constructed since the war. One of these is concerned solely with the development of machine-tool design, another with jigs and fixtures and a third with tools and equipment.

NEW ENGINE FOR VAUXHALL VELOX AND CRESTA

All-Synchromesh Gearbox

Vauxhall Velox and Cresta cars are now being fitted with a new, more powerful engine, and a new gearbox which has all three speeds synchronised. The engine has the same swept volume as the one it replaces, but installed horse-power is increased from 65 to 77 and maximum torque, as installed in the car, goes up from 107·5 lb. ft. to 114 lb. ft. It is a six-cylinder version of the four-cylinder Victor engine, with the same bore and stroke (79·375 × 76·2 mm.) giving 2,262 c.c. General design follows that of the four-cylinder units, with individual inlet ports to each cylinder, relatively large inlet valves of 1·437 in. diameter and improved streamlining of ports between valves and manifold. Volumetric efficiency at high revolutions is improved and the engine has the new Zenith 34 VN carburetter.

Cylinder block and crankcase are more robust, with skirts extending well below the crankshaft centre line. Stiff, short-throw crankshaft and large bearing areas add to engine life, and chromium-plated top piston rings are retained. Pistons are new, with offset piston pins as on the Victor, to minimise noise from slap when cold. The head is no longer of stepped construction, so all holding bolts are of equal length, making it easier to secure uniform pressure over the joint face. There is choice of two compression ratios. With 7·8 to 1, gross power is 82·5 b.h.p. at 4,400 r.p.m. and gross torque 124 lb. ft. at 1,800 r.p.m. With 6·2 to 1 compression maximum power is 77·9 b.h.p. at 4,200 r.p.m. and torque 117·6 lb. ft. at 1,200 r.p.m.

The gearbox is basically similar to that used for the Victor and, like it, has a cast iron casing instead of the aluminium casting previously used. The main motive for this is a reduction in cost. The new power unit will bring a considerable performance increase to the six-cylinder Vauxhall's at no extra price. It will presumably be retained when the time comes to produce a new six-cylinder car.

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JAGUAR FACTORY EXTENSION COMPLETED

A few days after the February fire at the Jaguar works, the order was placed for a new building of 80,000 sq. ft. where production could continue while the damaged part of the factory was reconstructed. The site was cleared, and construction began on March 11. Work continued seven days a week; 275 tons of steel and 3,250 tons of concrete were used, 1¼ miles of fluorescent lighting tubes were installed, and 12 weeks from the start, the building was practically ready for use. Data obtained from the inquiry into the fire was also used to reduce fire hazards in the design of the new building. The roof is of galvanised steel decking, with extensive use of " ply-glass " which diffuses the light and is said to reduce transmission of solar heat into the inside. There is no inflammable material on the underside of the roof, and there are ventilators operated by fusible links which in the event of fire open them to permit escape of hot air, fumes and smoke, which should slow down the spread of fire and make the task of fire fighting easier.

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HELPING THEM OUR WAY

Report of the Technical Assistance Board

The latest United Nations report on their technical assistance programme—the largest since operations were begun in 1950—and the recent statement by the American government on aid to Poland show that the willingness of the West, and particularly of the United States, to invest in economic resistance to Communism is almost limitless. Speaking in Washington, doubtless with the obstructive mood of Congress in mind, vice-President Nixon has observed that the United States had decided to give £34 million worth of economic aid to Poland " because we believe that the explosive power of freedom is great enough to destroy Communism, once it is given a chance to flourish."

After three and a half months of negotiation, an agreement was signed between the United States and Poland which covers surplus farm products and mining machinery. These will be made available immediately and covers about half the 95 million dols. agreed upon. The first 30 million dols. is to be in the form of credit to be administered by the Export-Import Bank, that most able agency of American trade. Much of the remainder is expected to cover purchases of wheat and cotton, which Poland badly needs, but little capital equipment. The agreement is unlikely therefore to affect very seriously the progress made in the Polish market by British engineering companies during the past year or so, progress now beginning to bear fruit.

The technical assistance programme of the United Nations, which is world-wide, is reviewed in the report of the Technical Assistance Board just published. In 1956, aid was provided in 103 countries and territories, and a total of 25 million dols. spent on field operations. Much remains to be done, but there is little doubt that the programme is helping countries to find their way in the exploitation of their natural resources and it is, on the whole, remarkably free from political influences.

RESEARCH CENTRE FOR AUSTRALIAN HEAVY INDUSTRY

Considerable advances in the industrial development of Australia are expected to follow the setting up of a new research centre in the steel-producing city of Newcastle, New South Wales. This busy seaport, with its blast furnaces and shipbuilding industry, 100 miles north of Sydney, has grown rapidly since the Broken Hill Proprietary Company, Limited, first established a steel plant there during the war of 1914-18; the town has now a population of 178,000.

The B.H.P., the abbreviation usually employed for the Broken Hill Company, which originated as a silver-lead mining concern at Broken Hill, western New South Wales, in 1885, now constitutes the largest single industrial enterprise in Australia, controlling iron and steel plants, ore leases, coal mines and shipping in various States. In March of this year the company opened an important new project, the Central Research Laboratories at Shortland, a suburb of Newcastle. Speaking at the official opening of the Laboratories, Sir Charles Goodeve, F.R.S., director of the British Iron and Steel Research Association, London, stated that the new establishment would quickly bring Australia to the forefront of world metallurgical research.

Fig. 1 (left) Central Research Laboratories at Shortland, Newcastle, New South Wales, of the Broken Hill Proprietary Co. Ltd., the largest single industrial undertaking in Australia.

In the past the development of Australia's productivity has owed a great deal to the information and technical help readily made available by older industrialised countries overseas. At present, however, Australia has entered a new phase, owing to the enormous increase in heavy industry, which took place during the war of 1939-45 and is still continuing. During that war, for instance, the B.H.P. had to produce special steels and many complex components for armaments to exacting specifications. Most of this work was done without overseas information or advice. In the post-war years the steel industry has had to face specific problems peculiar to the Australian environment and to develop new processes. It is no longer possible to solve such problems with techniques developed thousands of miles away. The company therefore decided to increase its research facilities, equipping its Newcastle Steel Works with laboratories for certain types of investigation.

Further research units were set up in other plants operated by the B.H.P. and its associated companies, notably at the iron and steel plant in Port Kembla, 50 miles south of Sydney, and at Whyalla, South Australia, where iron ore is smelted and where shipbuilding is carried on. Now that the Central Research Laboratories at Shortland have been completed a much larger research programme becomes possible. They will deal with the more fundamental, long-term questions, and will act also as co-ordinators for the other research units.

Investigations at Shortland will be carried out by the director of research, Dr. Howard K. Worner, and Dr. Frank Adcock, from London. The field of research will cover such varied matters as process metallurgy, coal and ore beneficiation, fuel utilisation, chemistry and chemical engineering, physical and mechanical metallurgy, physics and mathematics. In the early stages, the company states, the main projects will be associated with research into the use of raw materials rather than finished products. It hopes also to be able to assist overseas companies with problems of their own and thus return the advice and help given so willingly in earlier years. Ultimately the company expects to be able to make new products available in Australia and to assist in expanding trade to the countries of South-East Asia and elsewhere.

The commodious headquarters of the research centre have been built amid eucalyptus trees in a bushland setting, with plenty of space for future expansion. Existing buildings occupy some 22,000 sq. ft., and a general view of them is shown above. The two-storey scientific and administrative block contains offices, a conference room, a library, a first-aid room, and laboratories for basic research. Much of the ground floor is taken up by offices, but, at one side, are laboratories for metallographic and petrological work, with two associated dark rooms—one for microscopy and the other for general photography, microfilming and copying.

Fig. 2 (right) Chemical laboratories of the Shortland Research Centre, in which long-term fundamental scientific research, mainly in iron and steel, is carried out. The centre also acts as co-ordinator for other research units.

The upper floor, apart from three offices and the library designed to hold 10,000 books, is occupied by laboratories. There is a chemical laboratory, measuring 41 ft. by 34 ft., furnished with two independent fume chambers, each having a balanced-draught "air curtain" across the front to prevent the loss of conditioned air in the laboratory. The equipment includes a direct-reading balance, air-damped chemical and microchemical balances, a centrifuge, an electronic *p*H meter, an absorptiometer, electrodeposition apparatus, and a variety of ovens and furnaces. A view of a portion of the laboratory is shown below.

The adjoining fuel-chemistry laboratory has its own fume chamber and benches with water, gas, air, electricity, nitrogen and oxygen reticulated to appropriate outlets. It is equipped for the proximate and ultimate analysis of coal and coke, and for assays of coal for carbonisation, swelling index and plasticity measurements.

The X-ray and spectrographic laboratory, which measures 41 ft. by 17 ft., contains a fully-stabilised Philips P1010 X-ray diffraction apparatus with cameras and other accessories. The spectrograph is a large Hilger quartz unit. This section has its own dark room, while a small workshop next door is used for glass blowing and specimen preparation.

Across the corridor the general physics-electronics laboratory, 29 ft. in length and 17 ft. in width, contains electrical and electronics gear, including an oscillograph, a precision potentiometer, galvanometers and dilatometers for a wide variety of precise measurements and calibrations.

The single-storey technological block is an industrial type of building, 123 ft. in length and 60 ft. in width, with three roof bays, each 20 ft. wide and running the length of the building. At one end, a separate room, serving as a store, opens into the workshop which measures 60 ft. by 40 ft. Beside the store is a smaller room which is used as an instruments room, drawing office and headquarters for the chief technician.

In order to make the laboratories as independent as possible from outside help, the workshop is well-equipped for metal working. The design and construction of new machines and instruments, as well as maintenance work, will take place here. To this end, therefore, it contains a variety of lathes, a milling machine, a tool and cutter grinding machine, a vertical drill, saws presses and welding equipment.

Next to the workshop, the ore and coal dressing laboratory is fitted with standard-type crushing, grinding, sampling and sieving equipment. It is planned to build up a full range of machines for classification and concentration processes. Incoming loads of material can be delivered on to a steel mixing or sampling plate flush with the floor.

Another large room, 60 ft. long by 40 ft. wide, completes the block. This is reserved for a variety of processing operations. Equipment is (or soon will be) available in this laboratory to carry out such operations as mixing, leaching, filtration, centrifuging, distillation and evaporation. Furnaces for melting and heat treatment are installed, and it will be possible to assemble and operate pilot plants of moderate size. Mechanical-testing equipment here includes hardness machines, a small universal tester, and fatigue and creep machines.

A well-ventilated, all-metal pyrometallurgy building is situated close to the main centre. A hand-operated crane, suspended from heavy roof girders, makes possible vertical lifts of up to one ton anywhere within the building, except within 4 ft. of the side walls. A shallow casting pit has been provided in the reinforced-concrete floor. Other features of the pyrometallurgy laboratory are an electric-arc furnace which can melt up to 100 lb. of steel at a time, and a 20 kW induction melting unit, a billet-heating furnace, an air-operated forging hammer and an experimental sinter plant. Plans call for the installation soon of a small shaft furnace and a multiple oven for coal-carbonisation research.

SIMULATED-FLIGHT ENGINE-TEST FACILITY AT N.G.T.E.

1—AIR, POWER, WATER AND FUEL SUPPLIES

By W. G. Fletcher, M.ENG., A.M.I.MECH.E.

The reasons why, as aircraft speeds are rising well into the supersonic régime, it has become essential to carry out the development testing of aircraft jet engines under simulated flight conditions, were outlined in an article "The Simulated Flight Testing of Aero Engines," by Mr. Hayne Constant in last week's issue of ENGINEERING. *In the present article is described the engineering plant that has been, and is being, installed at the National Gas Turbine Establishment, Pyestock, in order to make such tests possible. The reasons underlying the arrangement of the plant and test cells, and details of the latter, will be given in a later article by Mr. R. P. Probert.*

To enable simulated flight testing of aircraft jet engines to be done it is necessary to provide air-compressing plant to direct the air on to the engine through suitably proportioned accelerating nozzles; a test cell or cells in which the local environment corresponding to the simulated altitude can be maintained; exhausters to remove the engine products and the air which spills over the engine intake; and means to heat, cool, dry and in other ways process the air used. This formidable array of equipment supplements rather than supplants the equipment for compressor, turbine and combustion-system development already existing at the National Gas Turbine Establishment and elsewhere.

A prime consideration of the engineers who planned the project at the National Gas Turbine Establishment was to find how existing facilities could be effectively integrated into the whole so as to make simulated flight testing possible several years earlier than had been anticipated.

A significant factor in reducing the cost of the plant is the continuing programme of research at N.G.T.E. on the aerodynamics of the test cells, with the object of finding the most efficient arrangement of the components, consisting of accelerating nozzles of variable expansion ratios, pressure-recovery diffusers for the engine and spill flow, coolers and other items. The basic object is to reduce the volume flow and pressure ratio necessary to simulate given flight conditions. Without the techniques which are now developed or being developed, the cost of the plant would be increased two or three-fold and would be beyond reach.

SITE LAYOUT

The integrated test facility consists of the following major groupings, the disposition of which is shown in the schematic layout of Fig. 1:

(*a*) The major air supplies are from two Metropolitan-Vickers compressors, from two Bristol Proteus compressors, and from eight General Electric Company compressors.

(*b*) The test cells, four in number, have the following functions:

No. 1 Cell.—For free-jet tests on ramjets and small jet engines throughout a range of altitudes and forward speeds. This cell takes air from any of the three supplies singly or in combination. The cell is evacuated by air-driven ejectors. A 3,000 kW air heater is used for preheating the air at entry to this cell and No. 2 cell.

No. 2 Cell.—For connected tests on ramjets and small jet engines. Air is available from the three supplies singly or in combination. The cell is evacuated by air-driven ejectors.

No. 3 Cell.—For free-jet or connected tests on engines of the largest type, having sea-level static air flows of up to 300 lb. per sec. This cell is equipped for icing tests and can operate through a temperature range at inlet from −70 deg. C. to +650 deg. C. Air is fed to this test cell from the G.E.C. compressors.

No. 4 Cell.—For free-jet testing of the larger engines. This cell is equipped with a variable Mach-number blowing nozzle and flight transients can be simulated. The air supply is taken from the G.E.C. compressors.

(*c*) An air drying and refrigerating plant operates on an air cycle using the output of one G.E.C. compressor. This plant feeds air into No. 3 test cell at temperatures down to −70 deg. C.

(*d*) An oil-fired air heater has an output of 36 × 10⁶ C.H.U. per hour with a maximum delivery temperature of 650 deg. C. This heater feeds cells 3 and 4.

(*e*) Cooling towers and reservoirs serve the three compressor installations and the test-area cooling loads.

The facility also includes (*f*) steam boilers and a superheater, (*g*) fuel storage and transfer equipment, and (*h*) workshops and assembly bays.

A description of the main supply services follows. The test cells, the refrigerating equipment and the air heater will be described in the article by Mr. Probert.

AIR COMPRESSING PLANT

The compressors and exhausters, which are a fundamental plant requirement, must be as flexible as possible to cover a wide range of conditions of pressure ratio, temperature and volume flow. A study of the test requirements

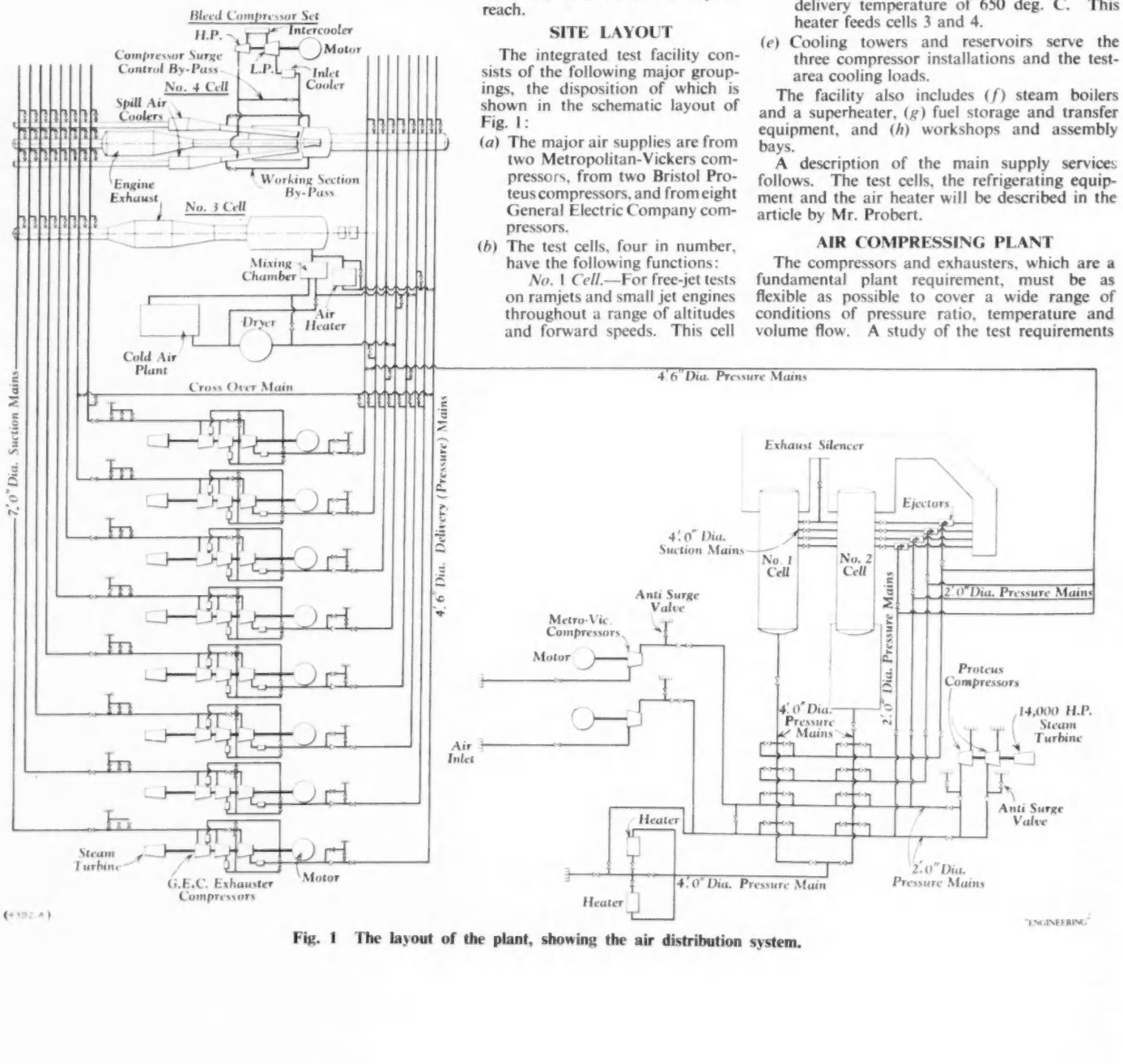
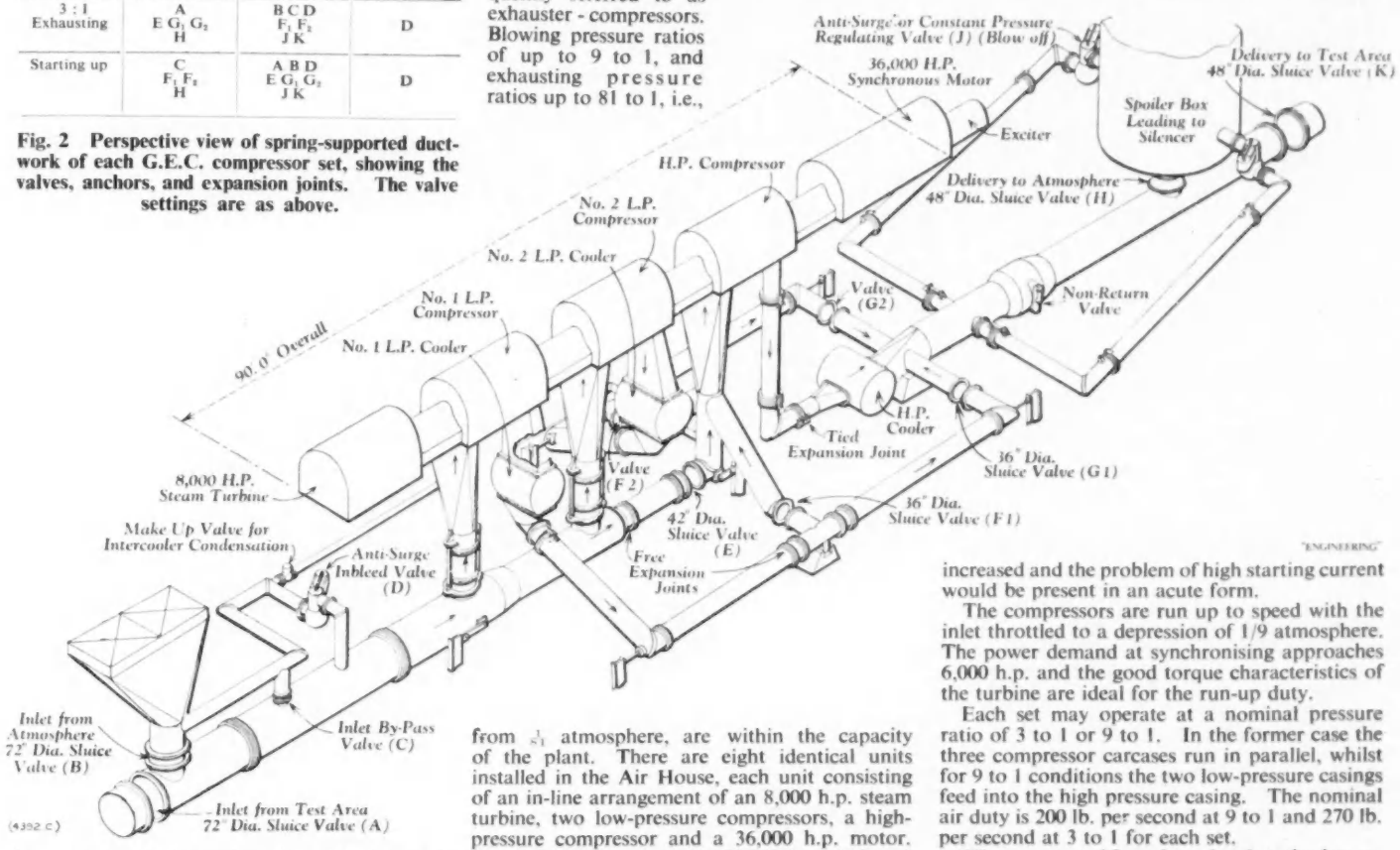


Fig. 1 The layout of the plant, showing the air distribution system.

Duty	Valves open	Valves closed	Valves opened by anti-surge gear
9 : 1 Compressing	B F_1 F_2 K	A C D E G_1 G_2 H J	
3 : 1 Compressing	B E G_1 G_2 K	A C D F_1 F_2 H J	J
9 : 1 Exhausting	A F_1 F_2 H	B C D E G_1 G_2 J K	D
3 : 1 Exhausting	A E G_1 G_2 H	B C D F_1 F_2 J K	D
Starting up	C F_1 F_2 H	A B D E G_1 G_2 J K	D

Fig. 2 Perspective view of spring-supported ductwork of each G.E.C. compressor set, showing the valves, anchors, and expansion joints. The valve settings are as above.


Anti-Surge or Constant Pressure Regulating Valve (J) (Blow off)
36,000 H.P. Synchronous Motor
Exciter
Delivery to Test Area 48" Dia. Sluice Valve (K)
Spoiler Box Leading to Silencer
H.P. Compressor
Delivery to Atmosphere 48" Dia. Sluice Valve (H)
No. 2 L.P. Compressor
No. 2 L.P. Cooler
No. 1 L.P. Compressor
No. 1 L.P. Cooler
90.0" Overall
Valve (G2)
Non-Return Valve
H.P. Cooler
Tied Expansion Joint
36" Dia. Sluice Valve (G1)
8,000 H.P. Steam Turbine
Valve (F2)
42" Dia. Sluice Valve (E)
36" Dia. Sluice Valve (F1)
Make Up Valve for Intercooler Condensation
Anti-Surge Inbleed Valve (D)
Free Expansion Joints
Inlet from Atmosphere 72" Dia. Sluice Valve (B)
Inlet By-Pass Valve (C)
Inlet from Test Area 72" Dia. Sluice Valve (A)
(4392 C)
"ENGINEERING"

shows the need for exhausting, blowing and exhausting and blowing together.

The Metropolitan-Vickers air supply, in the Plant House, consists of two identical units each capable of delivering 60 lb. per second of air at a pressure of 6 atmospheres. The compressor is of the axial-flow type having 17 stages and is driven by an 8,850 h.p. synchronous induction motor through step-up gears. The motor speed is 1,000 r.p.m. and the compressor speed is 7,150 r.p.m. An aftercooler is provided and by means of a by-pass system, delivery air temperatures are available within the range 50 deg. C. to 250 deg. C.

The second air supply is taken from two Bristol Proteus compressors which are coupled together in line and driven by a 14,000 h.p. steam turbine. This steam turbine is designed for high-speed operation and is directly coupled to the Proteus compressor without the need for step-up gears. The output is 80 lb. per second at a pressure of 6 atmospheres and a temperature of 250 deg. C. The Proteus and Metropolitan-Vickers compressors are run in parallel and feed a total of 200 lb. per second of air to cells 1 and 2. If greater supplies are required—and these cells are designed to accept flows up to 600 lb. per second—then the third air supply from the G.E.C. compressors can be used, alone or in conjunction with these supplies.

STEAM-TURBINE/SYNCHRONOUS MOTOR

The G.E.C. compressors can operate also as exhausters and will, for this reason, be subsequently referred to as exhauster - compressors. Blowing pressure ratios of up to 9 to 1, and exhausting pressure ratios up to 81 to 1, i.e., from $\frac{1}{9}$ atmosphere, are within the capacity of the plant. There are eight identical units installed in the Air House, each unit consisting of an in-line arrangement of an 8,000 h.p. steam turbine, two low-pressure compressors, a high-pressure compressor and a 36,000 h.p. motor. The eight units aggregate 352,000 h.p., believed to be the biggest compressor installation of its kind in the western world. The particular combination of steam turbine and synchronous motor is also believed to be unique in its present application. All the compressors are of the centrifugal type. The estimated performance of each set is shown in Fig. 3.

The principal function of the steam turbine is to start the set, but it may also continue to give power after the motor is synchronised and will in fact be required to do so when the set is operating as a 9 to 1 compressor. The largest power demand occurs during cold winter conditions when the steam turbine is required to deliver about 6,000 h.p. The choice of drive was influenced to some extent by the existence of steam supplies on the site. It is technically sound on its own merits since it obviates the rather fearsome problem of independent geared starting motors and the heavy current demands at starting. An induction-motor drive would present power-factor difficulties at low loads (exhausting duties) and such a machine would necessarily be of slow speed with very large speed-increasing gears. The civil-engineering cost for foundations and buildings would thus be increased and the problem of high starting current would be present in an acute form.

The compressors are run up to speed with the inlet throttled to a depression of 1/9 atmosphere. The power demand at synchronising approaches 6,000 h.p. and the good torque characteristics of the turbine are ideal for the run-up duty.

Each set may operate at a nominal pressure ratio of 3 to 1 or 9 to 1. In the former case the three compressor carcases run in parallel, whilst for 9 to 1 conditions the two low-pressure casings feed into the high pressure casing. The nominal air duty is 200 lb. per second at 9 to 1 and 270 lb. per second at 3 to 1 for each set.

When connected for exhausting duty the depression at inlet may be 3 to 1 or 9 to 1, and can be extended to 27 to 1 or 81 to 1 by the interconnection between the ductwork ouside the Air House. The volumetric capacity when exhausting will be as in Table I, page 782.

Each of the three compressors has four stages

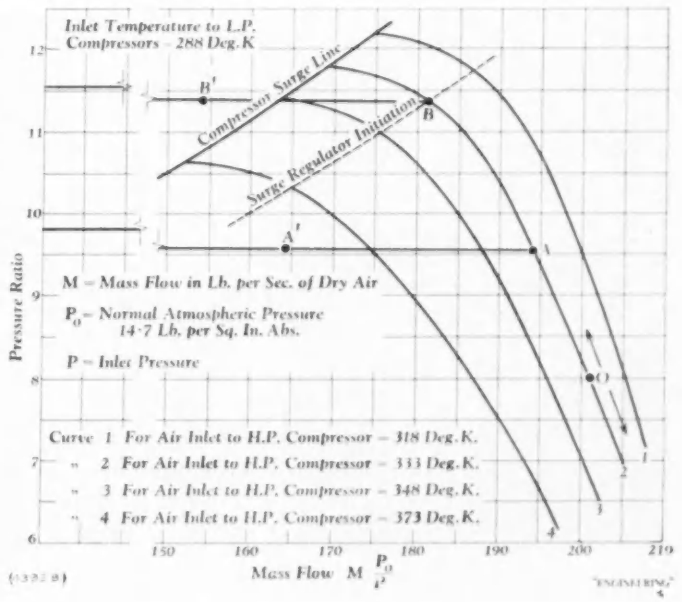


Fig. 3 Compressor characteristics—high-pressure compressor in series with low-pressure compressors.

Curve (1)	Air inlet to h.p. compressor	318 deg. K.
" (2)	" " " " "	333 " "
" (3)	" " " " "	348 " "
" (4)	" " " " "	373 " "

The functioning of the surge regulator is as follows:

Throttling the supply to the test cell will cause the operating point "O" to rise up the curve until it reaches the point "B." Further throttling will cause the regulator to blow-off sufficient air to maintain compressor conditions at point "B," in spite of a reduced quantity of air being fed to the test cell.

Under any conditions below the dotted line, variations in mass flow will cause variations in pressure ratio, which is undesirable. This is overcome by the constant pressure regulator, which can be pre-set to any desired value. The operating point "O" will then rise until the point "A" is reached, whereafter the pressure ratio will remain constant and the surplus air will be blown off.

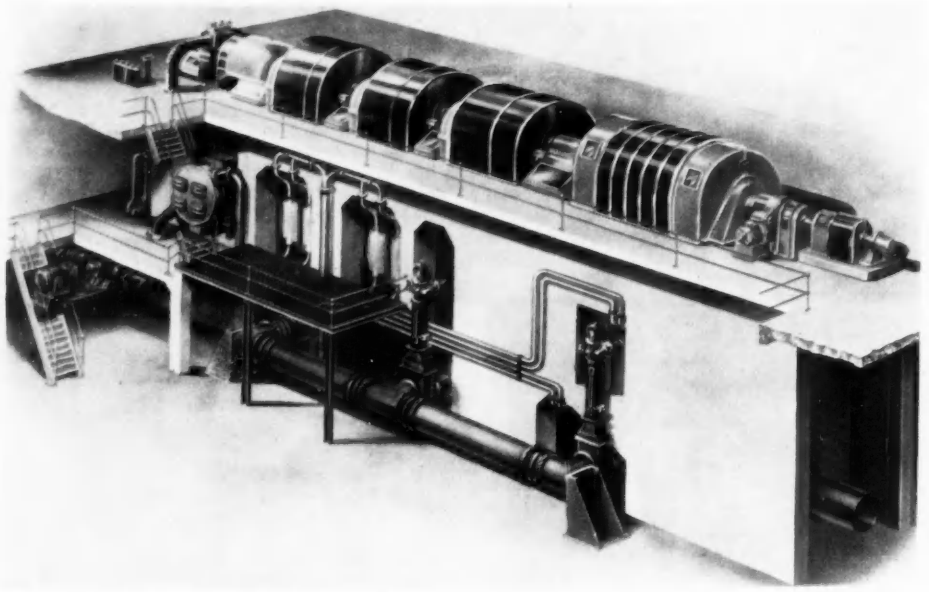


Fig. 4 Artist's impression of the G.E.C. exhauster-compressor, showing, from left to right, 8,000 h.p. steam turbine, two low-pressure compressors, high-pressure compressor, 36,000 h.p. synchronous motor and finally the exciter.

TABLE I.—*Volumetric capacity of G.E.C. exhausters*

Pressure ratio	Volumetric capacity, cub. ft. per min.
3 to 1	$1{\cdot}68 \times 10^6$
9 to 1	$1{\cdot}25 \times 10^6$
27 to 1	$1{\cdot}09 \times 10^6$
81 to 1	$1{\cdot}09 \times 10^6$

with 60 in. diameter impellers. The low-pressure casings are cast iron and the high-pressure casing is cast steel. Each stage is fitted with aluminium diffuser vanes carried in detachable plates so that a change of characteristic is not impossible.

The delivery air temperature is adjusted by means of intercoolers and an aftercooler giving a range from 50 deg. C. to 250 deg. C. at the 9 to 1 condition. The air passes in cross flow over two banks of extended surface Integron tubes. Between these two banks of tubes is a free-way through the cooler, the air being directed over the tubes or through the free-way by internal dampers which are motorised for remote operation from the control room. The air circuit can be followed from the perspective view in Fig. 2. Fig. 4 is an artist's impression of the set and Figs. 5 and 6 show the compressor foundation blocks under construction using Kwikform steel shuttering. The plinth height is 26 ft.

SUPPRESSING SURGING

For operational safety it is necessary to avoid large fluctuations in the power taken from the supply authority, and also to avoid surging of the compressors, both of which conditions may arise from mal-operation or mishap at the test cell, resulting in the breakdown of the air flow pattern. To reduce the ill effects of such an occurrence, bypass valves will be provided at the test cells which will maintain the air flow and pressure drop in the circuit as nearly constant as possible. Similar conditions may be met when engine transients are being simulated, and in this case the bypass system is to be coupled to the main air flow so that a set pattern of engine air-flow conditions is provided.

In addition to the test-cell protective devices, anti-surge regulators are provided for blowing and exhausting conditions. Means are provided for operation at constant pressure with infinitely variable selection of the pressure ratio within the limits of $2\frac{1}{2}$ to 1 and 9 to 1 when blowing. This will be backed up by a true anti-surge regulator which will allow of approach within approximately 10 per cent. of the surge-line pressure at the various permitted inlet temperatures. The effect of these two methods of control will be appreciated by further reference to Fig. 3. With anti-surge control, the relation between delivery pressure and mass flow will be dictated by the characteristic curve of the compressor since the operating point will move along this curve. This change of pressure with flow is in many cases undesirable because of its effect on the control valves at the test cells. With constant-pressure control the operating point will move along an artificial curve as dictated by the pre-set pressure, and having the minimum of droop necessary to give stability to the control system. The small variation of pressure with flow allows a more predictable operation of the test-cell control gear.

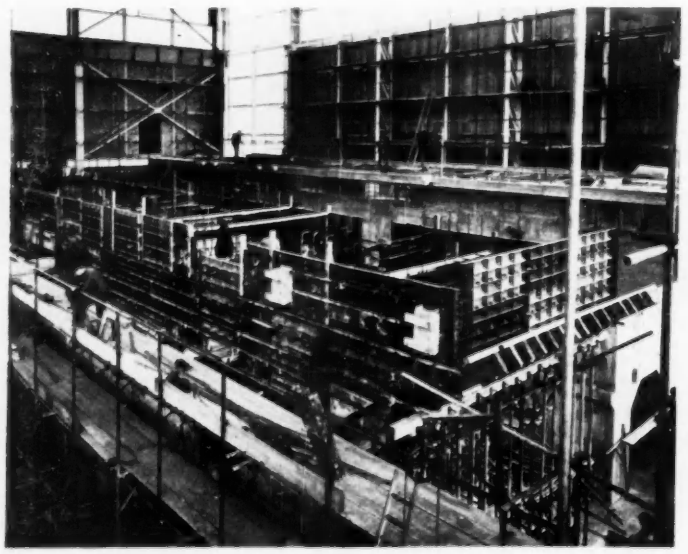
The blow-off valves, two per set, are each 18 in. in diameter and are of a vertical-lift poppet type, giving approximately linear area of blow-off with lift. The valves are actuated by oil cylinders fed from the turbine governor supply, and in case of dire emergency it is possible to trip these valves and dump the full air flow in one second.

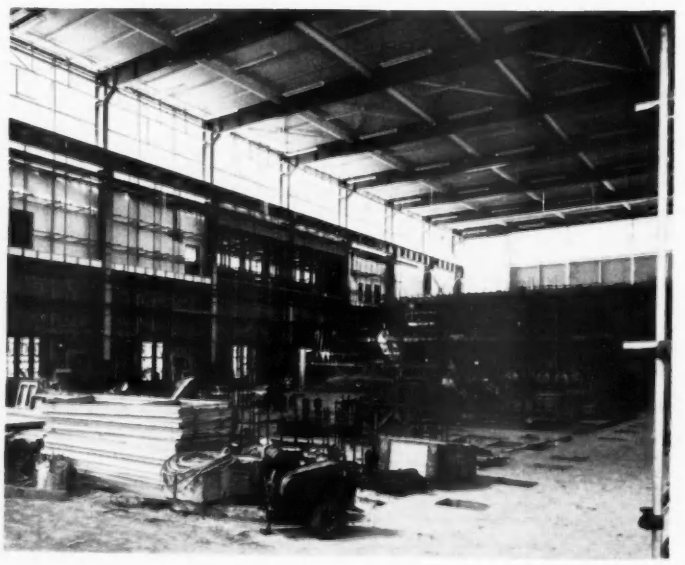
When these blow-off valves are in operation means must be provided to dissipate the kinetic energy of the issuing jet, which is of considerable destructive power. The jets enter a spoiler box forming an annular chamber around the rising duct entering a silencer. In this chamber the velocity is broken down and the air then enters the rising duct through a large number of 1 in. diameter holes. There is thus no possibility of damage to the silencer from impingement of the main high-velocity jet.

There is considerable noise generated in the destruction of the kinetic energy of the air and also from the running of the machines, and in order that working conditions will be tolerable and the surrounding areas not inconvenienced it is necessary to provide the silencer referred to previously. It is not possible to know beforehand what the absolute level of the noise generated will be. It is, therefore, desirable to couch the specification in terms of a minimum acceptable reduction in noise level which, within the relevant frequency bands, is as follows:—

Frequency band, cycles per sec.	Attenuation through silencer, decibels
37·5–75	8
75–150	16
150–300	24
300–600	33
600–1,200	48
1,200–2,400	59
2,400–4,800	63
4 800–9,600	63

Air is filtered at entry to the sets to avoid erosion of the compressors and test units. The atmosphere is free from the more normal types





Figs. 5 and 6 The foundation blocks for the G.E.C. sets under construction. The effective use of Kwikform steel shuttering is shown on the left.

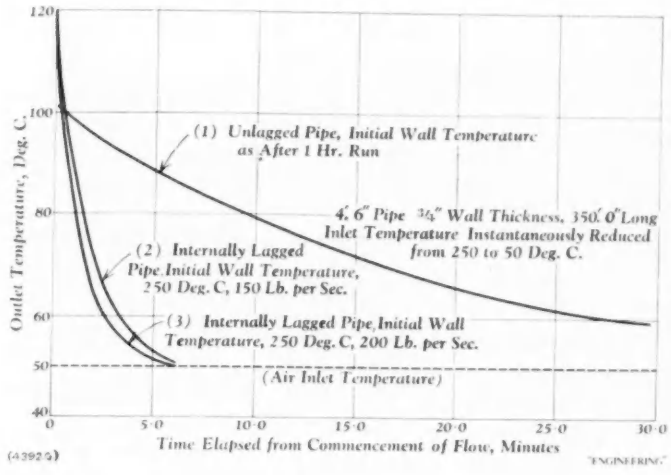

Outlet Temperature, Deg. C.
120
100
80
60
50
40
0
5·0
10·0
15·0
20·0
25·0
30·0
(1) Unlagged Pipe, Initial Wall Temperature as After 1 Hr. Run
4' 6" Pipe ¾" Wall Thickness, 350' 0" Long Inlet Temperature Instantaneously Reduced from 250 to 50 Deg. C.
(2) Internally Lagged Pipe Initial Wall Temperature, 250 Deg. C, 150 Lb. per Sec.
(3) Internally Lagged Pipe Initial Wall Temperature, 250 Deg. C, 200 Lb. per Sec.
(Air Inlet Temperature)
Time Elapsed from Commencement of Flow, Minutes
(43924)
"ENGINEERING"

Fig. 7 (left) Temperature response of an internally lagged pipe and an unlagged pipe during a cooling cycle when the entry temperature is instantaneously reduced to 50 deg. C.

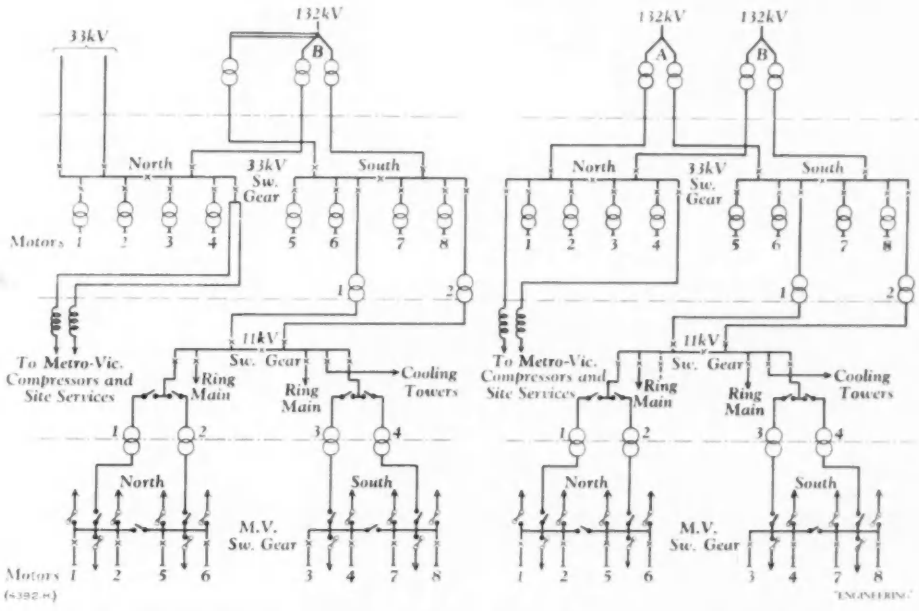


Fig. 8 (below) The electrical distribution system. The left-hand diagram shows the present arrangements with an intake of 40 MW at 33 kV and 120 MW at 132 kV, whilst on the right it is shown how the power will be increased when the second line at 132 kV is brought in, the 33 kV supply being discontinued.

of pollution found in industrial districts, but fine sand is known to be a difficulty. Vokes Kompak filters are used, each machine requiring two banks each consisting of 180 filter units with a frontal area 22 ft. by 18 ft.

If wet products are being handled, condensation will take place in the intercoolers leading to mismatching of the high and low-pressure stages. Although it is not the intention to operate with very wet products, a system for extracting water and automatic inbleeding of make-up air is designed, but not installed.

Preliminary investigations on the cost of the compressing plant indicated most clearly the considerable advantage of using the largest units available. Not only was the plant shown to be cheaper, but there were secondary gains on the civil engineering side. As a general principle in this class of work it can be said the units should be as large as possible whilst still maintaining the necessary flexibility in operation which test requirements demand. It is of doubtful validity to argue that the unit compressor size should be determined by the minimum flow requirement.

In relation to the actual running hours, which are not considerable on this type of plant, it is sound policy to use a larger unit and accept the need for air dumping when the smallest air flows are required. The running costs are increased a little, but the volume flows may be increased up to 30 per cent. for the same investment, and the wider range of usefulness of the plant is much the better bargain. If there is a demand for a continuous small air flow from a plant on a grand scale then it is better to provide a small set to meet this demand whilst applying the principle of the largest unit possible for the rest of the plant.

DUCTWORK AND THE AIR DISTRIBUTION

The operational flexibility which is built into the air-moving plant cannot be effectively used unless the air-distribution system is similarly flexible in use. The utmost in operational versatility is achieved if the intakes and deliveries of each unit of air-moving equipment are kept separate throughout the test area. This plan has been adopted and, as far as can be seen, it will obviate future modifications to the layout, which, in ductwork of this size, is a matter of some difficulty. Furthermore, the engineering problems associated with the ductwork are eased because the ducts are smaller.

Air is delivered to cells 1 and 2 through 2 ft. diameter mains which pass along the front of the test cells and are fed from one end by the two Metropolitan-Vickers compressors and from the other end by the two Proteus compressors. Ram air is taken from these mains through a 4 ft. diameter connection to the front end of the cells. Bellows-type expansion joints, tied and untied, are used throughout this system.

Air is fed from the G.E.C. sets to these cells through a single overhead main, 4 ft. 6 in. in diameter. This main passes over the ejectors, which are fed via 2 ft. diameter connections, and is then further connected into the mains passing along the front of the cells. The valves are so arranged that the three air supplies can be used in any combination.

The arrangement of the ductwork connecting test cells 3 and 4 to the G.E.C. exhauster-compressors is such as to allow exhausting, compressing, or exhausting-and-compressing in combination at any of the pressure ratios previously mentioned. In addition to this, closed-circuit operation is possible at pressure ratios of 3 to 1 and 9 to 1, and by the use of the cross connection which feeds the delivery of one group of exhausters into the inlet of a second group, even up to 81 to 1. The air distribution diagram, Fig. 1, shows how these combinations are achieved. To avoid feeding pressure air into the inlet of the high-pressure unit of the cascade of compressors, the cross-over main incorporates relief valves which will vent the full flow for a pressure rise of 3 lb. per sq. in. above ambient.

Air is delivered to cells 3 and 4 through eight pressure ducts each 4 ft. 6 in. in diameter whilst the exhaust connections are 7 ft. in diameter. The air velocities vary with the test and lie in the range 50 to 150 ft. per sec. Cascade elbows are used wherever possible, the aerodynamic design being based on N.G.T.E. and other work. It is known from experience at N.G.T.E. that these elbows are prone to failure due to air-induced vibrations of the cascade vanes. In a recent failure, certain of the vanes had broken into small pieces 4 to 5 in. long. The normal velocities in air ducts are sufficient to carry these pieces along the duct into downstream equipment. In the case quoted the pieces entered a static plant—a 1,500 kW electric heater with sheathed elements—and the damage was small. The consequences could hardly be less than disastrous if such debris entered a plant compressor or a test engine. In the design of cascade elbows it is prudent to observe these points: (*a*) The vanes should be cross-braced to increase damping and reduce the amplitude of vibration. (*b*) The vanes should not be designed as structural members of the elbow, i.e., the elliptic centre portion of the elbow should be made self-supporting against the internal fluid pressure by adequate external ribs. (*c*) A cascade elbow should not follow immediately after a valve because of the uneven flow and high local velocities which are met in such positions. In certain failures the presence of a valve has been a contributing cause. (*d*) Adequate stress relieving after welding is essential. (*e*) If thermal cycling is a normal operational condition, and it usually is, the vanes will be relieved of differential thermal stresses if only one end is solidly welded, the other end being pocketed for location only.

THERMAL EXPANSION

The accommodation of thermal expansion has given rise to interesting pipework problems which have been variously solved by the use of tied and untied expansion joints, i.e., direct compression joints and hinging joints, and earth anchors. It is, perhaps, around the machines that the most severe problems were met, because nothing could be left to chance in view of the disastrous consequences of any unrelieved expansion forces being transmitted to the compressor casings. The whole of the ductwork, intercoolers, aftercoolers and valves is spring-supported and weighs upwards of 150 tons per set, but loads transmitted to the casings are not expected to exceed one ton. A perspective view of this ductwork is shown in Fig. 2.

In the ductwork outside the buildings the number of earth anchors (i.e., points where the full fluid thrust is transmitted to earth) has been kept to the minimum in view of the civil engineering work involved. It is normally cheaper to use tied expansion joints, although certain configurations of ductwork demand earth anchors and anchors may also replace such a number of tied joints as to reverse the economics. A tied expansion joint is of considerable proportions, and is costly, having to resist a parting force of 250 tons in the case of the 4 ft. 6 in. diameter pressure mains (test load). Within the confines of the test area of cells 3 and 4 there are so many take-off points that the use of earth anchors is the correct and perhaps the only solution. The horizontal ducts between the two confining anchors, which delineate the test area, incorporate only free joints and in this

case they are Viking Johnson couplings. The use of these couplings in this manner, to accommodate axial movements due to expansion and also a functional hinging action, is unusual and requires careful attention to the joint ring material and its lubrication, to avoid scuffing of the material. The saving in first cost as against any conventional type of bellows joint is very considerable, in view of the large numbers of joints involved.

Quick thermal response is a matter of great importance. The thermal capacity of the mains is so high as to impose considerable delays whilst the desired temperature conditions are being achieved. This is costly, due to idle running of the plant, and presents almost insurmountable problems when it is required to simulate transient conditions which require quick changes in temperature of the air delivered to the engine. A considerable improvement is possible by the use of internal heat liners. These consist of 16 s.w.g. stainless steel formed to a diameter 2 in. less than the internal duct diameter, thus giving a gap of 1 in. between the liner and duct wall. This void is adequately vented to prevent collapse of the lining due to a rapid change of pressure in the duct. The estimated improvement in response, in the case of the cooling cycle, is shown in Fig. 7. In the heating cycle, internal shielding likewise effects a considerable improvement in response. The mains so treated will not be externally lagged unless operating experience indicates the need.

POWER SUPPLIES

It has been stated previously that the maximum demand for shaft power is 352,000 h.p. (262,500 kW). The immediate test programme does not require all the machines to operate at maximum load so that, as a measure of economy, the initial electrical power intake is to be restricted.

The Central Electricity Authority has agreed to the siting of a 275 MW sub-station of the supergrid at Fleet some four to five miles from the site. From this point the power is brought to site at 132 kV by overhead line and cable. Due to the proximity of air fields, towers adjacent to the site are not permissible. In the first instance a single feeder of 120 MW will be provided, with facilities at both ends, and at all road and water crossings, for duplication to bring the power up to 2 × 120 MW with the minimum of disruption and cost. The power supply to the site at present is 2 × 20 MW at 33 kV and this will be continued, so that the total to site will be 160 MW. This will not be fully available, however, because these supplies cannot be paralleled, but supplies up to 150 MW will be regularly used.

Fig. 8 shows the distribution arrangements. The G.E.C. sets are fed in pairs from 60 MW, 132/33 kV transformers. Each 11 kV motor is solidly coupled to a 33/11 kV 27·5 MW transformer and the switching is done at 33 kV on account of rupturing capacity and general economics.

The control room and switch rooms are in an annexe along the side of the Compressor House, with the control room centrally situated and overlooking the engine-room floor. The 33 kV switchgear is in two separate rooms, one on each side of the control room. The battery room and medium voltage and 11 kV switchgear are also in this annexe. The 33 kV switches are single busbar 600 ampere rating, vertically-isolated oil-immersed with a rupturing capacity of 750 MVA. Bus section switches divide the sets into groups of two and are of 1,200 ampere rating. The incomers are also 1,200 ampere rating. Site services are taken from an 11 kV ring main fed from a 10 MVA transformer at each end.

In addition to the electrical panels, the control room also contains the air desks, one to each set, and a complete air mains diagram for the test area. Fig. 9 shows the air desk control diagram. The sets, having been put on to the governor gear, are synchronised and completely controlled from this desk. Fault indications are received here of excess bearing temperature, cooling water failure, stator temperature, etc. It is important to maintain the air supply to the test cells, and for this reason automatic shut-down is restricted to major mechanical or electrical faults, which have been found to be, of themselves, the prime cause of shut-down.

It is the control-room engineers' responsibility to assess the fault signals received and to give as much warning as possible to the test engineers before shutting down, if this should prove to be necessary.

In addition to the electrical power, there are three steam boilers, each having a capacity of 150,000 lb. per hour at 400 lb. per sq. in. and 625 deg. F. Since the running hours are relatively short, the need for efficiency is not paramount and no economisers are fitted. The boiler house is 1,000 ft. from the compressor hall, steam being conveyed through two steam mains each 10 in. in diameter. An automatically-fired superheater is located close to the compressor hall to maintain the correct stop-valve conditions at all steam loads. To over-come some of the problems of cold steam lines, the heating of the new buildings is from live steam taken from the power steam lines.

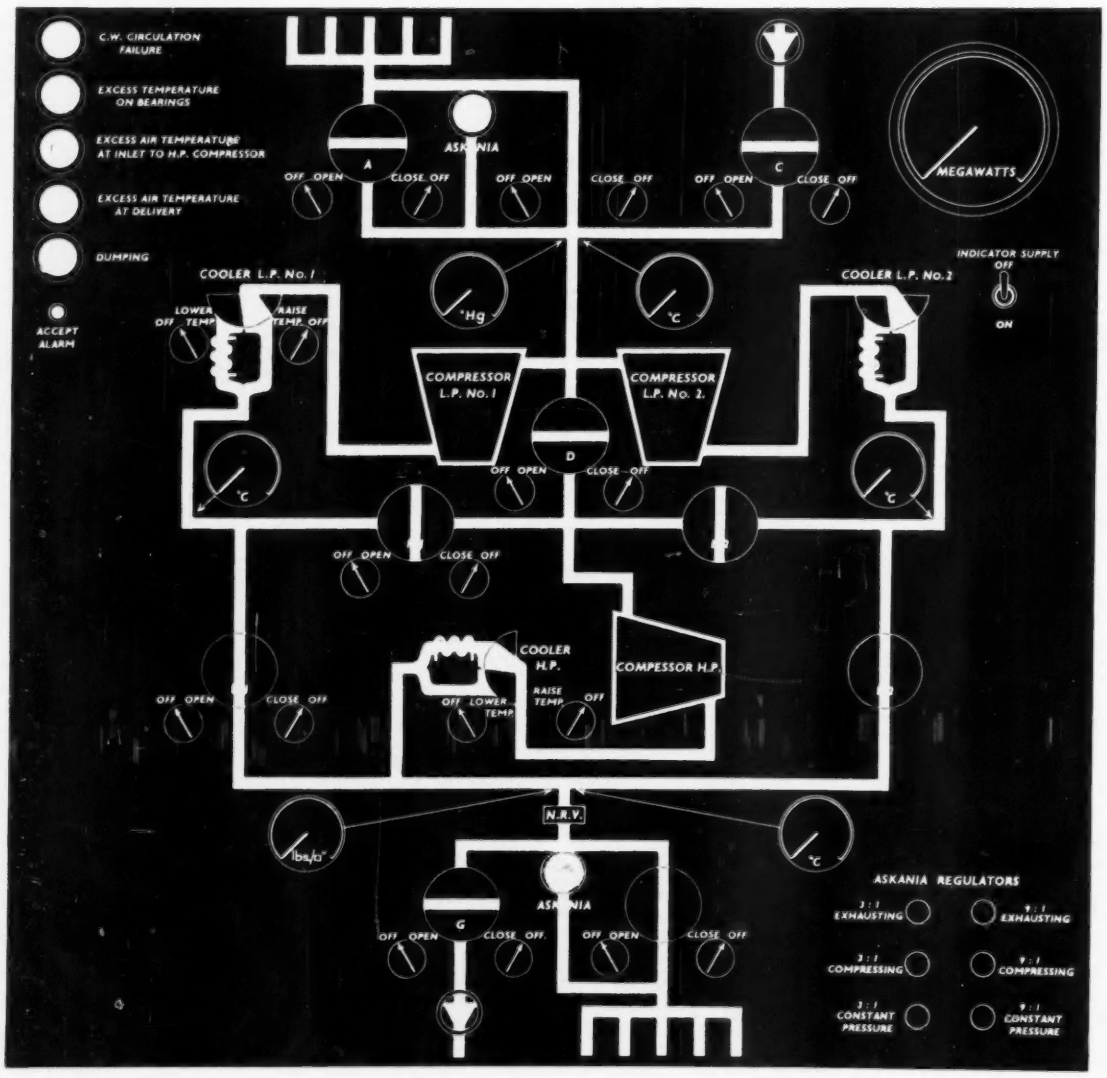


Fig. 9 The air control diagram as seen by the plant controller. The control buttons are next to the valves operated.

WATER SUPPLIES AND COOLING SYSTEM

Because of the restricted operating times, a typical feature of large test plants, the actual usage of water is small, and is not expected to exceed 1,000,000 gallons a day. Nevertheless, the circulated water quantities are considerable, being of the order of 8,000,000 gallons an hour. The main cooling systems are divided between the air-compressing plant and the test area. Because of the short running hours, the economics are in favour of mechanical draught towers as opposed to natural draught towers.

The cooling tower for the G.E.C. exhauster-compressor plant consists of eight cells each passing 500,000 gallons per hour and each cell having two induced-draught fans driven by 55 h.p. motors. The structure is continuous, the ponds being separated by reinforced-concrete walls. The ponds can be drained separately for maintenance. The water flow to the troughs is valved so that the flow circuits can be similarly isolated. At times of severe frost and low cooling duty, difficulty has been experienced due to freezing, so facilities have been provided to return the water

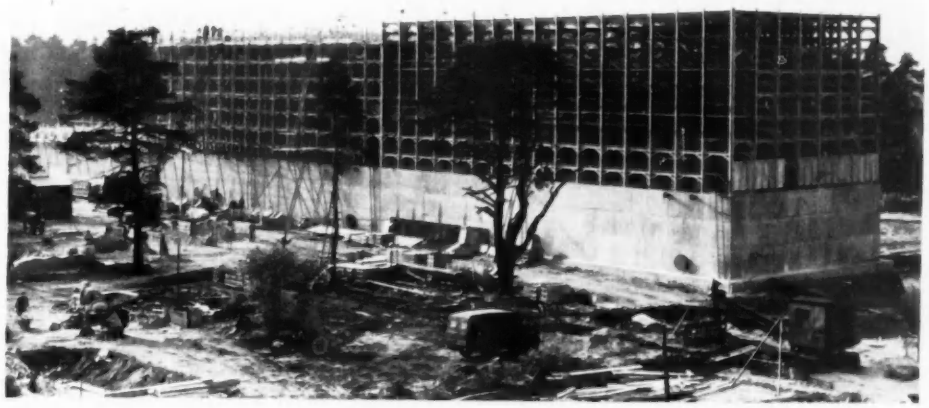


Fig. 10 Head Wrightson cooling tower. The superstructure is built up from prefabricated reinforced-concrete sections, giving a saving in first costs. The towers are 396 ft. long and 46 ft. wide with 16 fans.

directly to the ponds, by-passing the tower completely. Fig. 10 shows this tower in the course of construction.

The water flow from the tower to the compressor house is by gravity through a reinforced-concrete flume below ground level. This was constructed on site, and it does not form part of the foundations. The water is returned to the tower through two Stanton prestressed concrete ducts, 4 ft. 6 in. in diameter, the sections being joined with Viking Johnson couplings, housed in two trenches running along the plant hall and separated by a load-bearing wall from which the central columns of the plinth rise.

The circulating pumps at the sets are horizontal split-casing units with 24 in. inlet branches each absorbing 330 b.h.p. and delivering against a head of 100 ft. The three air coolers for each set are in parallel and are fed by water which has first passed through the condenser, thus reducing the circulated-water quantity. This economically desirable system is made possible because the steam turbine is required to operate at full load only in severe weather conditions when the compressor load is a maximum, and accompanying this is a much improved performance of the cooling towers, which leaves the overall performance unimpaired.

The cooling towers for the Metropolitan Vickers exhauster-compressors and the Battle House steam turbine are again of the induced draught type for the reasons as stated above. Water is stored on the site, in three 1,000,000 gallon circular prestressed concrete reservoirs.

FUEL STORAGE AND HANDLING

Fuel for steam raising and test use is stored in a central tank farm containing 12 tanks each of 80,000 gallons capacity. The fuel is transferred to the test area or the boiler-house day tanks through low-head pumps. It is particularly desirable where day tanks are in use to be able to drain down the tanks with the least delay in case of fire. The units used for this duty are vane-type pumps on which the eccentricity of the rotor with respect to the block can be varied, and can in fact be moved to either side of the neutral position of no delivery.

In collaboration with the manufacturers, Plenty and Son, the potentialities of this unit were developed some four years ago for N.G.T.E. use. Constant-pressure regulation, irrespective of flow or end restriction, is attained automatically by controlling the eccentricity of the block. This is positioned by a hydraulic cylinder to maintain constant outlet conditions measured either at the pump or some remote point.

The block, which is held in its normal flow position by a catch, is spring-loaded towards its reverse-flow position, and the catch can be remotely released to give an instant reversal of flow in case of emergency.

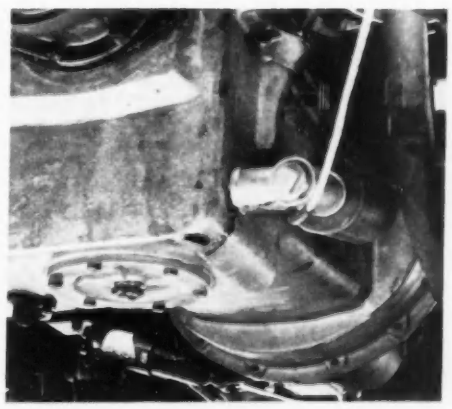
Acknowledgment:—The furtherance of this project has depended to a very marked degree on the close and effective collaboration between the National Gas Turbine Establishment and the Heavy Plant Division of the Ministry of Works.

★ ★ ★

HEATER-CHARGER

Starting Engines from Cold

A unit which should prove of considerable help in starting internal combustion engines in cold weather, has been developed by Power Frequency Heating, Limited, Alexandra-road, Hounslow, Middlesex. Called the Peregrine, it is a combined heater and battery charger. Its action is to heat the engine lubricating oil direct thereby reducing the viscosity and enabling the starting equipment to turn the engine fast enough for an immediate start. Some heat is also supplied to assist in vaporising the fuel. The Peregrine uses electromagnetic induction and operates from the standard mains supply. A magnetic field is set up in a steel tube which is used as part of the core of a transformer. The tube is therefore heated by the hysteresis and eddy current effects. The unit is fixed to the side or bottom of the crankcase, and is inclined so that the oil in the sump circulates through the heated tube by convection. The arrangement can be seen in the illustration. In this way the oil can be quickly heated from cold or maintained warm continuously. The hot oil naturally also tends to heat the whole of the engine. At the same time, low-voltage current is supplied from a secondary winding of the unit, rectified and used to trickle-charge the battery. The unit consumes approximately one kilowatt-hour in eight hours continuous operation. During this time it will maintain an oil temperature of 120 to 150 deg. F.



An induction heater fitted to the engine sump warms the oil for easy starting.

CHOICE OF THREE RADAR DISPLAYS

Various types of presentation may be used for marine radar. In the " north stabilised " system a gyro-compass is connected in to the equipment, and it controls the display so that true north is always directed at 12 o'clock on the screen. In the " ship's head up " system 12 o'clock represents the direction in which the ship's bow is pointing. In another system, " track indication," the centre of the radar picture traverses the tube in a manner representing the actual track and speed of the vessel.

Each system has its own advantages. The north stabilised display enables anchor bearings to be quickly checked; the ship's head up system is useful where the angle on the bow or the relative bearing is needed; the track indication system permits a rapid assessment of the traffic situation.

A new radar track indicator has been designed by the Marconi International Marine Communication Company, Limited, Chelmsford, Essex. It is for use with the Marconi Marine " Quo Vadis XII " and " Radiolocator IV " equipments and may be added to existing installations. By means of a switch the operator can select the type of presentation best suited to his needs. All information concerning course, speed, and tidal conditions is fed into the track indicator continuously and automatically, the last being preset on a control unit. As the ship's position approaches the edge of the screen a warning note informs the operator that the display needs resetting. During the traverse of the display across the face of the cathode ray tube, the true bearing of any target can be determined by switching on an electronically generated flash which radiates from the observing ship's position.

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EYE STRAIN AND INFRA-RED

" Glass blower's cataract " is a well-known term for the lenticular opacities which frequently develop in the eye as a result of constant exposure to infra-red radiation. Other fields of activity also have infra-red as an occupational hazard. In particular, office workers who spend a large part of their time in artificial light can blame it as a frequent cause of eye irritation.

Recently, a glass has been developed that transmits visible light but absorbs infra-red radiation strongly in the region of wavelength 1100 mμ. Unlike previous glasses, which were of a green or almost black tint and consequently impracticable to wear indoors, the new glass, Uropal, has an almost invisible skin-like tint.

Manufactured by the Oberkochen plant of the Zeiss Foundation, Western Germany, the glass is available not only in plain glass but also to any optical prescription. It is significant to note that of the total light radiated by a 100 watt electric lamp, over 85 per cent. is invisible and 80 per cent. has a wavelength of 1100 mμ.

★ ★ ★

400 kV POWER TRANSFORMER

A single phase transformer suitable for 400 kV at 50 c/s has been produced by the British Thomson-Houston Company, Limited, Rugby. The weight has been reduced by about a third, as compared with conventional designs. The windings are designed for auto connection and are of the fully-shielded concentric-layer type. The mechanical strength of the windings was tested at the Switchgear Testing Company's testing station at Manchester: the transformer successfully withstood through-fault currents up to 13 times the continuous rated value. The transformer tank was given oil-pressure tests and was found to withstand without permanent distortion, and without any temporary bracing, the application of an internal pressure of 15 lb. per sq. in. Prototype equipment such as this provides useful design information for the new high voltage transmission schemes.

MEASURING SMALL DISPLACEMENTS*

PNEUMATIC METHOD FOR OBSERVING LIFT IN TURBINE SHAFTS

By C. A. Scoles

Synopsis.—The paper describes an instrument developed to carry out accurate measurements of turbine shaft displacement during running conditions of extreme severity, where the presence of heat, steam, and water, together with the need for a non-tactual and remotely indicating measuring system, precluded the use of normal available measuring equipment. Instead, a pneumatic gauge was devised which successfully overcame the difficulties of measuring and, at the same time, provided the necessary wide measuring range of 0·015 in., a range normally considered to be beyond the scope of an open-jet system.

The problem was put to the Laboratory by a Glasgow shipbuilding firm†, of determining the precise amount of turbine-shaft lift which occurred when a turbine was accelerated progressively from rest to maximum speed. The lift was to be measured in terms of the relative movement between the main bearing casing and the rotating shaft itself, allowing for the fact that considerable thermal expansion of both components would occur at different rates during the operation. In addition, the site of measurement would be subject to the presence of hot wet steam escaping from the main stator casing, and would be very inaccessible due to the compact design of the machine and the obstructions caused by its associated pipework, all at a high temperature.

It was necessary, therefore, to evolve a form of measurement capable of indicating a movement as small as 0·0002 in. and having an overall range of about 0·015 in. in order to accommodate likely thermal dimensional changes additional to the changes due to the shaft lift itself. The method had to be a non-tactual one, so that the abrading action of the rotating shaft would have no deleterious effect on its long-term behaviour, and in addition would have to be unaffected by heat, steam and water, and be capable of providing a remote indication of the dimensional changes to which it would be subjected.

DESIGN OF INSTRUMENT

For simplicity and cheapness it was considered that these requirements could best be met by an open-jet pneumatic gauge, where a small jet unit would be the only part to be located in the restricted space available for the measurements. The rest of the equipment, housed in a small cabinet, could then be placed some yards away from the turbine in more congenial surroundings and connected with the jet unit by a flexible tube. This technique is similar in principle to that suggested by Guy‡ in 1922 for measuring axial displacement of turbine shafts, using oil as the working medium.

Due to the rather large working range of the unit (0·015 in.) it was necessary to use a very large jet orifice of approximately $\frac{5}{16}$ in. diameter. Two different circuit arrangements were tried out with this jet, the first, Fig. 1, being one in which the control orifice was located within the cabinet, that is, at a distance of some 8 ft. from the measuring jet. With this system it was found that the small line resistance of the tubing connecting the two orifices was of significance in that a change in the length of the tube affected the calibration of the gauge. In view of this, the complete instrument was calibrated using a certain length of tubing to connect the measuring jet to the cabinet, and it was essential that no subsequent alteration was made to this length.

The second system was adopted later when it was considered that the self-cooling action of the measuring jet and air-tubing might not be sufficient in cases where turbines were operated under steam temperature conditions approaching 800 deg. F. The normal calibration of an air gauge remains constant only if the air between control jet and measuring jet is subject to adiabatic changes, and this would not be the case if the measuring jet were to be placed in close proximity to a very hot turbine while the control orifice remained at room temperature at some distance from the source of heat. For this reason the system shown in Fig. 2 was adopted. The brass jet unit was modified to enable the control jet to be located within the brass body of the measuring jet, so that in service both orifices would be subjected to the same heating effects. A small diameter pressure pick-off pipe was soldered into the flank of the jet body and connected to the calibrated gauge, Fig. 3. Two tubes were thus needed to connect the jet unit to the cabinet, but the system, apart from being largely insensitive to temperature effects, also had an improved speed of response. A point of interest noticed during the construction of the second type of jet unit was that the depth of insertion of the pressure pick-off pipe into the jet body affected the sensitivity and calibration of the gauge, owing to the pressure gradient across the jet body in the vicinity of the control orifice.

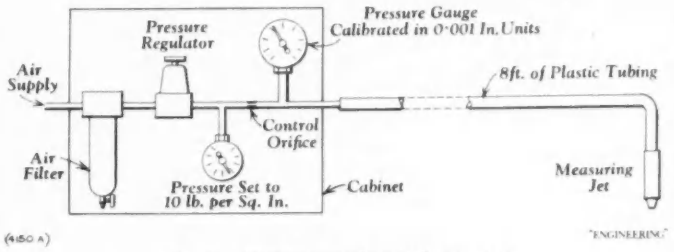


Fig. 1 First pneumatic gauging system.

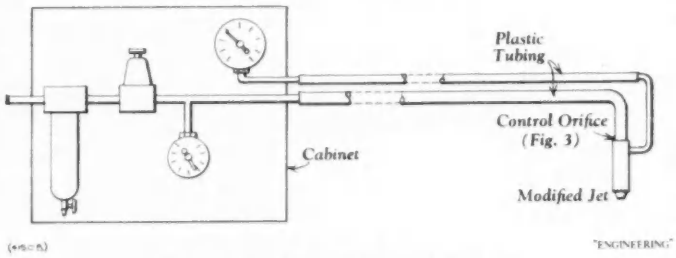


Fig. 2 Second pneumatic gauging system.

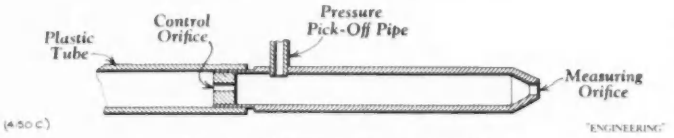


Fig. 3 Modified measuring jet unit.

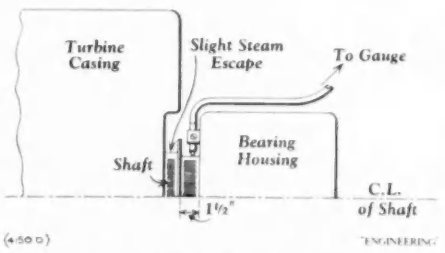


Fig. 4 Showing location of jet on turbine.

The brass jet unit was then mounted in the tool-post of the lathe and adjusted to bear squarely on the flank of the disc at its centre-line height. Controlled 0·001 in. feed-ins of the jet unit were then made in order to calibrate a plain dial fitted to the pressure gauge, and subsequent repeat calibrations made with the disc rotating slowly and then at speeds up to 2,200 r.p.m. revealed no discernible change from the initial readings. It was thus proved that no "windage" effects resulted from the motion of the disc over this speed range. Insensitivity of the modified jet system to temperature change was verified by heating with a Bunsen burner a short length of copper tubing inserted in the air line close to the jet unit. Despite this rather drastic treatment, which raised appreciably the temperature of the air passing through the jet unit, no significant changes in readings were observed.

It is generally preferred to use instruments with linear scales if possible. However, with a direct jet system as described above, previous experience indicates that the linear part of a pneumatic gauge scale corresponds to a maximum displacement at the measuring jet of approximately 0·003 in., which provides a pressure change between control orifice and measuring jet of about 50 per cent. of the supply pressure* (i.e., from about 0·4 to 0·9 times the supply pressure). In order to increase the range it is necessary, therefore, to work on the non-linear part of the characteristic curve relating back pressure and displacement. It was found experimentally that, with a supply pressure of 10 lb. per sq. in., a gauge pressure change from about 2 to 4½ lb. per sq. in. corresponded to a displacement at the measuring jet of 0·015 in. A pressure gauge of 0 to 5 lb. per sq. in. range was used to increase the sensitivity of the system, care being taken to ensure that the measuring jet was never closed completely to avoid overloading this pressure gauge.

CALIBRATION OF INSTRUMENT

A steel disc having approximately the same diameter as the turbine shaft was ground to a high degree of roundness and surface finish and mounted on a true mandrel in a precision, high-speed toolmakers' lathe, the final run-out of the disc being less than 0·0001 in.

SHOP TRIALS

In the actual shipyard shop trials the first type of jet arrangement was used. Two turbines were to be tested side by side, and therefore the instrument was fitted with a switched three-way outlet, three identical air-tubes and three identical jet-heads, so that a single jet could be fitted on one turbine to measure its vertical lift component (Fig. 4) and two jets on the other turbine to measure both horizontal and vertical components of its rotor shaft displacement. Readings from any jet could be taken at will be merely resetting the three-way air-switch. In order to allow for the thermal expansion effects, the jets were attached to the "cold" turbines and adjusted

* Communication from the Department of Scientific and Industrial Research, Mechanical Engineering Research Laboratory, East Kilbride, Glasgow.

† Alexander Stephen & Sons, Ltd., Linthouse.

‡ British Patent No. 202,691 (1922).

* *The Engineer*, vol. 192, pages 62-64, July 13, 1951.

in turn to read zero on the recalibrated pressure gauge. During the warming-up period of the turbines with their shafts turning very slowly, zero changes were observed.

Once the turbines were up to temperature and the main steam turned on, measurements were taken progressively against turbine shaft speed, and at the end of the trials the gauge readings were noted at the instant the shafts came to rest, thus enabling true zeros for the three sources of measurement, with the metal of the turbines still at its full running temperature and the shafts " dropped " in the white-metal bearings.

During the trials it was noted that the jet units and the plastic tubing in the live steam area were dripping with condensed steam, yet were only slightly warm to the touch, thus indicating the efficiency of the natural cooling action of the large air flow through them. The temperature of the steam used during these shop trials, however, was not very high.

SEA TRIALS

The sea trials were carried out some months later, and since it was known that the degree of steam superheat to be used at sea was considerable, the modified jet units were constructed to overcome the expected high temperature difficulties. Measurements at sea were restricted to one turbine, provision being made for using one vertical jet and one horizontal jet, each connected to its own calibrated pressure gauge. In this way, the need to switch continually from one jet to the other for the purposes of taking readings of lift was avoided.

Measurements were taken at sea during two separate full day trials of the ship, and it was observed on both occasions that various progressive changes in apparent lift occurred during the hours the turbine was running, which were obviously due to differential expansion changes between the turbine shaft and the bearing housing. Unfortunately, it was not feasible to stop the turbine frequently in order to establish zero lift readings at the various thermal conditions applying, and hence the results obtained were not as useful as had been expected.

It had been supposed that, to a large extent, the turbine would have settled down more or less to steady thermal conditions once it had been running for an hour or so, but in fact it appeared that the relative dimensions of the shaft and bearing changed fairly quickly in accordance with the power output of the turbine at any given time.

During the second sea trial, the plastic air-tube supplying the horizontal jet melted with the heat, close to the jet body, where it had to lie near to the hot bearing housing. This trouble could be avoided by using copper tubing on the jet unit, coupled to plastic tubing farther away from the bearing. It was noted during pronounced rolling of the ship that a rise and fall of the turbine shaft of about 0·0005 in. occurred at the roll frequency.

CONCLUSIONS

It would appear that this method of measurement, applied under shop trial conditions, which is simple and inexpensive to provide, forms a satisfactory answer to the general problem of turbine shaft attitude determination under adverse running conditions. The same method could be equally successful at sea providing that the turbine could be stopped occasionally, especially at the start and finish of any full power runs, in order to establish zero lift readings. No provision of extra measuring stations on the turbine can overcome this requirement.

The method is not suitable for measuring dynamic eccentricity (due to transitional warping, etc.) nor critical vibration of turbine shafts owing to its time response lag, but for steady displacement measurement under suitable conditions, this feature is of no significance, and the results obtained are more than sufficiently accurate for the purpose.

Acknowledgments.—The work described was carried out in the Mechanisms and Metrology Division of the Mechanical Engineering Research Laboratory as part of the research programme of the Mechanical Engineering Research Board. It is published by permission of the Director of the Laboratory. The facilities provided by Alexander Stephen and Sons, Limited, at their shipyards and at sea are gratefully acknowledged.

TORSIONAL WAVES IN WIRES

Disc-Loading Increases Computer Memory

Remembering one group of figures while calculations are carried out on another group is an important procedure in calculation. This is true whether or not the calculator is human. Automatic computers generally use electrical pulses as a basis for calculation and it is essential that some sort of store be provided for such pulses. A basic method is to send the pulses on a journey, the route of which is arranged so that they are intercepted when the intermediate step of calculation has been completed.

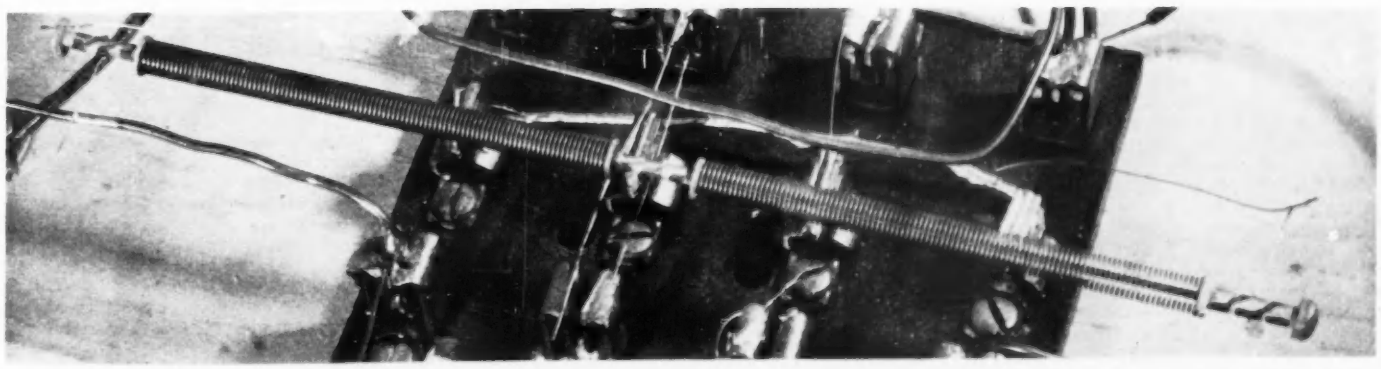
Sending electrical pulses on a journey of any length of time requires a considerable length in space, since the pulses travel at the speed of light. The alternative generally employed is to transform the pulses into their analogue in a medium which has a lower velocity. The surface of a rotating magnetic drum is widely used. The pulses are transformed into magnetised dots, after which they move at the peripheral speed of the drum. In many circumstances this procedure is satisfactory and the magnetic drum usually forms the main store of a computer. However, for some applications the drum-storage time is too long.

Electro-mechanical delay lines have short storage time and can be used as an alternative to the magnetic drum. There are various types of such delay lines. A well tried one is the mercury line in which the electrical pulses are transformed into pulses of compression travelling through a mercury column. One of the disadvantages of the mercury delay line is its bulk. Smaller lines can be attained by using a solid medium and transforming the electrical pulses into pulses of torsional strain. The time delay in such a line or rod depends on the velocity of propagation of the wave of torsional strain. A large decrease in velocity, and consequently an increase in storage capacity, can be got by disc loading, in which the rod is composed of alternate large and small diameter sections.

Delay times per unit length as much as 25 times greater than those of unloaded lines have been achieved by the Bell Telephone Laboratory, New York, with disc-loaded lines. One of their experimental delay lines, machined from a solid brass rod, is shown in the illustration; the diameters of disc and rod are 0·180 in. and 0·045 in., respectively (that is to say, a ratio of 4 to 1).

In designing a delay line the frequency to be transmitted is as important as the delay time. The maximum frequency passed determines the sharpness of the pulses and the closeness with which they can be spaced. The loaded line acts as a filter to torsional waves, and above a certain cut-off frequency severe attenuation occurs. The cut-off frequency decreases with increase in diameter, spacing and thickness of the discs. To attain a high cut-off frequency, small dimensions are necessary. But the delay for a given length increases roughly as the square of the ratio between the disc and rod diameters. Thus, large delays at reasonable operating frequencies require small diameter rods and precise machining. The cut-off frequency of the line shown is about 50 kc/s.

The torsional transducers designed for the tests were produced from barium-calcium titinate. Two types were used. One was a split tube type, 3·14 cm. long and 0·255 cm. in diameter, the other was a dumbell or disc-loaded type, analogous to the line itself and only 1·43 cm. long. These transducers were soldered to the ends of the brass delay lines. The delays were measured by first determining the delays in the transducers themselves, and then soldering the lines between them, the line delay being the difference between that for the coupled transducers and that for the line-transducer assembly. At the test frequency of 32 kc/s the delay was 43 microseconds per centimetre, with an insertion loss of 1·7 db, for the 4: 1 line with 0·020 in. discs and spaces and a total length of 2½ in. The bandwidth was determined by the transducers and was 4·6 kc/s. A 5:1 line was constructed with 0·015 in. discs and a total length of 3 in. The delay obtained was 114 microseconds per centimetre, the insertion loss about 1 db, and the bandwidth 6·3 kc/s. The torsional wave delay in a brass rod of uniform diameter is 4·5 microseconds per centimetre.



Electrical pulses to the elements at the end of the disc-loaded rod are transformed into pulses of torsional strain. The delay caused by the time of travel of the torsional pulse along the rod is determined by the dimensions of the rod and discs. During their time of travel the pulses can be considered as stored in the rod, and consequently such a rod can be used as a memory unit in a computer.

Book Reviews

HEAT WITHOUT CONTACT

Induction and Dielectric Heating. Electricity and Productivity Series No. 6. *British Electrical Development Association*, 2 *Savoy-hill, London, W.C.*2. (8*s.* 6*d.*)

Conventional methods of heating rely upon one or more of the three basic principles of heat transfer, i.e., radiation, conduction or convection. They are familiar to all by personal experience, if not by name, in the respective forms presented by the sun, the hot water bottle and the hair drier. Industrial heating techniques must perforce also rely upon the transfer of heat from an external heat source to the work—often a slow and inefficient process. The principle of electric resistance heating (the subject of the fifth book in the E.D.A. Electricity and Productivity Series) requires the passage of an electric current through a metal or other conductor, e.g. an electric fire, and only rarely can this conductor be the work-piece itself. In almost every case the problem of heat transfer remains.

In induction and dielectric heating, however, the difficulty does not arise, as electrical energy is employed to generate heat in the substance of the work-piece itself. In consequence the rate of heating can be many times faster than that offered by conventional methods. The amount of energy converted to heat can be controlled accurately and production cycles repeated rapidly and precisely. Working conditions are improved, operating skill becomes less necessary and productive capacity per unit of floor area is increased. Induction and dielectric heating are not necessarily applicable with advantage to every heating problem, but increased production, improved products and reduced costs can be achieved when these techniques are correctly utilised.

The book sets out to dispel some of the mystery surrounding these forms of electric heating, to demonstrate their essential simplicity and to illustrate the types of application for which they are most suitable.

Although analogous in many respects, induction heating and dielectric heating differ in fundamental principle and each has distinct fields of application. Two basic phenomena are involved. Induction heating relates to metals and other electrical conductors, in which eddy currents are set up when they are placed in the magnetic field of an alternating current, thereby causing heat to be generated. Dielectric heating relates to non-metals and poor electrical conductors, which, when placed in a powerful alternating electric field, suffer molecular disturbance by which heat is generated.

The book makes a further division of its subject matter into three parts: (1) induction melting of metals; (2) induction heating for metal heat treatment; (3) dielectric heating. Part 1 describes the oldest and widest application of induction heating—the melting of metals, dating from the circular-hearth furnaces of the early Nineteenth Century. Progress is traced through the two major developments—the vertical secondary channel of Wyatt, and the coreless, crucible based design of Northrup—to the present day, when furnace bodies range up to 8 tons in capacity and rotating generators from 10 kW to 2,500 kW in output.

Part 2 induction heating for metallurgical purposes, is by far the longest of the sections. When a.c. eddy currents are set up in a conductor they are most dense on and near the surface. The higher the frequency the more pronounced this effect becomes. By the correct choice of frequency and rate of energy input it is possible to heat the surface layers of a component to any desired depth while the core remains relatively cool. Suitable quenching when the requisite skin temperature is reached makes possible elegant methods of surface hardening—methods which facilitate the mass production of machine parts by unskilled operators. Other important uses discussed are "through heating" for rolling and forging, annealing, brazing, soldering and welding.

The third part, on dielectric heating, describes applications mainly in the field of plastics and synthetic resins. Production rates and uniformity of product in the compression moulding of thermosetting plastics have been greatly improved by the dielectric heating of preforms. Thermoplastic materials can be readily fused, welded, seamed or sealed and many uses are found in plastics fabrication. A chapter is devoted to dielectric heating in the woodworking industry, where modern urea formaldehyde and other synthetic resin adhesives are rapidly and efficiently cured by radio-frequency electric fields. A final chapter describes miscellaneous uses of R.F. heating in the foundry, textile, ceramic and food-product industries.

The many examples and illustrations are well presented and the argument rightly focuses on the heating problems involved and the economics of manufacture, with a commendable minimum of electrical detail.

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RADIO JOINERY

Practical R.F. Heating for the Wood Industry. By J. POUND. *Heywood and Company, Limited, Ingersoll House*, 9 *Kingsway, London, W.C.*2. (30*s.*)

Mr. Pound's book, as its title suggests, brings to bear upon the subject of radio frequency heating a practical outlook which is essential if it is to be acceptable to the woodworking industry. The book should prove of great assistance to the technician or junior executive wishing to acquire a basic knowledge of the functioning and capabilities of this relatively new tool.

The opening chapter is devoted to adhesives. The performance characteristics of urea formaldehyde resins, which are the type in most general use, are given in some detail. Adhesive formulations and applications for use in conjunction with R.F. heating are also given and the need for applying sufficient pressure and for controlling the rate of heating is emphasised. Although implied, no specific explanation is given of the fortuitous suitability of thermosetting synthetic resins, and U.F. resins in particular, for use in conjunction with R.F. heating. In the absence of such an introductory explanation, the logic of discussing adhesives at the outset may be questioned, though it is admittedly difficult to suggest a suitable alternative position for such an important complementary subject.

The chapters immediately following outline the general principles of R.F. heating and describe the design of various generators in common use in the industry. This section is particularly lucid and the reasons for choice of frequency as well as for limitations on assembly sizes are clearly explained. Some useful data are given to assist in the calculation of approximate curing cycles. It is, however, difficult to see why the chapter on "Matching" is not included in this part of the book instead of following the section dealing with particular applications. Chapters 4 to 8 deal in great detail with the subjects of the most efficient jigging methods, and the various methods of heating—transverse, glue-line and stray field.

The inclusion of a chapter on other methods of heating appears, at first sight, to be outside the legitimate scope of the book as defined by its title, but is in fact necessary for the final chapter on relative costs to be fully appreciated. The economics of the process are adequately discussed and the author observes that, although R.F. heating can enable great savings to be made in time and cost, this is not invariably the case and he stresses the fact that, in certain operations, it offers no advantage over more conventional heating methods. Indeed, "incorrectly applied it may be an expensive luxury."

The glossary of technical terms is fairly comprehensive and numerous clear diagrams illustrate many of the points discussed in the text: the photographs, while helpful, vary considerably in quality. The author has covered thoroughly the existing field of applications, the furniture and radio cabinet industries being extensively drawn upon for illustration. It is surprising that other potential applications have not been discussed at greater length, e.g., the use of R.F. heating in chipboard manufacture where a large increase in production is anticipated within the next few years. The book, as a whole, represents a very creditable attempt to bridge the gap between the electrical specialist and the less highly qualified practical man who may require a readily understandable introduction to the subject of radio frequency heating. For readers wishing to pursue the subject further, the author has been thoughtful enough to include a list of references.

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HANDLING NUMBERS

Mathematical Tables. Volume 1. By L. Fox. *Department of Scientific and Industrial Research, Charles House*, 5-11 *Regent-street, London, S.W.*1. (17*s.* 6*d.*)

Mathematical tables have a history extending almost as far back as that of mathematics itself for the discovery of each new mathematical function has generally created a demand for a tabulation of its numerical values. To the preparation of such tables an immense amount of labour has been devoted both by individual computers and by teams of computers. So tedious and time consuming was the task of numerical computation during what may justly be termed the heroic age of table making that tabulation was normally confined to the more commonly encountered functions and, even then, did not always include the desired number of significant figures or a sufficiently fine argument interval or cover the requisite range.

The whole position has been radically transformed within recent years by the development of high-speed computing machines and these machines enable such defects in existing tables as those mentioned to be readily remedied and make the tabulation of the higher and more specialised types of mathematical function a feasible undertaking.

One of the duties of the Mathematics Division of the National Physical Laboratory, formed in 1945, is the construction of new mathematical tables and the checking and extension of existing tables. The present volume constitutes a general introduction to the forthcoming N.P.L. Mathematical Tables Series and is divided into three parts. Part A, on the use of Mathematical Tables, includes considerations governing the choice of tabular matter, presentation and accuracy, notation, the use of auxiliary functions, direct and inverse interpolation in single entry tables, first and second derivatives, definite integrals and interpolation in tables of two variables. Part B is devoted to the theory and error analysis of throw-back formulae of interpolation and of economised interpolation polynomials. One appendix collects together various formulae for interpolation, differentiation and integration and lists the corresponding error terms, while another provides a generalised theory of throw-back interpolation and criticises certain conclusions of Kopal.

Part C deals with computational methods now employed in the construction of mathematical tables and such related matters as the calculation of zeros, linear algebra, the evaluation of derivatives and integrals, the solution of ordinary, integral and partial differential equations. Among the miscellaneous techniques described are iterative procedures, recurrence relations and subtabulation. The importance of selecting the

most advantageous method is stressed and sound advice is given on checking. This volume contains no tables but discusses, authoritatively, topics of general interest to all concerned in the construction and use of mathematical tables. The care and thought expended upon this preliminary planning is in the best tradition of the National Physical Laboratory and augurs well for the scope, accuracy and usefulness of the series of mathematical tables that are to follow.

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NEW BOOKS

Electrons Go To Work. By J. GORDON COOK. *George G. Harrap and Company, Limited, 182 High Holborn, London, W.C.1.* (12*s.* 6*d.*)

A member of the "Science for Everyman" series, this book sets out to describe in simple language the various ways in which electrons are used. The structure of matter is explained with emphasis on the part played by electrons. Radio communication and radar are described and also television and the electron microscope. The final chapters are concerned with transistors and printed circuits, and automation.

Foundations of Wireless. By M. G. SCROGGIE. Sixth edition. *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1.* (12*s.* 6*d.*)

The sixth edition of this book differs from the fifth chiefly in its inclusion of a chapter on semi-conductors. The work covers the basic theory of radio, starting from elementary principles. No previous technical knowledge on the part of the reader is assumed. Early chapters deal with the fundamental laws of electricity and radio. The theories of valves, transmitters, and receivers are described, and there are introductions to the techniques of television and radar.

Fires in Industry. The British Occupational Hygiene Society's Sixth Conference. Edited by C. N. DAVIES. *Engineering Ltd., 35 and 36 Bedford-street, London, W.C.2.* (10*s.* 6*d.*)

The British Occupational Hygiene Society was formed in London in 1953 as a central organisation to provide for the requirements of doctors, scientists, industrialists and others interested in maintaining the full bodily efficiency, wellbeing and safety of men and women at work. The progress of the Society in membership and influence since its inception is a measure of the need for such a body. From the beginning, it has been the practice of the Society to hold two conferences a year on important aspects of occupational hygiene. The most recent of the series was devoted to "Fires in Industry," and comprised a series of papers on the surest methods of avoiding such disasters, and the best means of minimising risks to men and materials. There were also papers on extinguishing fires and aiding the injured. A summary of the conference appears in our issue of November 23, 1956, page 663, and the present publication (which is well illustrated) contains the papers and discussions. Greatly increased attention is now being directed to the problem of diminishing industrial fires, consequent, among other things, upon the disaster at the Coventry factory of Jaguar Cars Limited on the evening of February 12. Prevention is always better than cure, and a record of these proceedings of the Society's conference will inevitably open up many avenues of thought on preventive measures.

Publications Released by the British Electrical and Allied Industries Research Association, *Thorncroft Manor, Dorking-road, Leatherhead, Surrey:*

Wind Data Related to the Generation of Electricity by Wind Power, by J. R. Tagg, C/T115 (30*s.*); The Effect of Series Resistance on the Ignition of Methane-Air Gas Mixtures by Capacitive Discharges, by H. G. Riddlestone, G/T304 (7*s.* 6*d.*); Life-testing of Impregnated Paper Capacitors: Variability of Results, by H. F. Church, L/T336 (7*s.* 6*d.*); Polarization of the Continuous Spectrum in a Gas Discharge, by B. V. Paranjape, L/T338 (6*s.*); On the Polaron Rest Energy and Effective Mass, by G. R. Allcock, L/T342 (21*s.*); Oscillographic Observation of Short Duration Arcs between Separating Platinum and Palladium Contacts, by J. Riddlestone, U/T135 (12*s.* 6*d.*)

The Final Forming and Shaping of Wrought Non-Ferrous Metals. *The Institute of Metals, 17 Belgrave-square, London, S.W.1.* (21*s.*)

The various processes dealt with in this report of a symposium held in London on the occasion of the annual general meeting of the Institute of Metals, on April 12, 1956, include machining, deep-drawing and spinning, rubber pressing, cold roll-forming, stretch-forming, bending and hot-forming.

The volume, which constitutes No. 20 of the Institute's Monograph and Report Series, contains the eight papers forming the symposium, together with the discussion upon them.

The Mechanism of Phase Transformations in Metals. *The Institute of Metals, 17 Belgrave-square, London, S.W.1.* (50*s.*)

This volume is designated No. 18 of the Institute of Metals Monograph and Report Series and contains 18 papers forming a symposium organised by the Metal-Physics Committee of the Institute and held at the Royal Institution, London, on November 9, 1955. The discussion which took place is also included.

The symposium was divided into two parts, one dealing with nucleation-and-growth processes and the other with martensitic transformations. For each part a long and comprehensive paper was invited, and this was followed by a number of shorter papers describing original work in the field concerned.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Automatic Analysis of Steel. HILGER & WATTS LTD., 98 St. Pancras-way, London, N.W.1. The analysis of carbon, phosphorus and sulphur in steels with a new instrument, the "fluorite Polychromator." This makes use of resonance lines of the elements in the far ultra-violet or Schumann region. The instrument is a three-prism spectrograph in a drum-like container, 18 in. in diameter, mounted on a cabinet housing the necessary vacuum apparatus and the measurement and control equipment. Descriptive leaflet.

Valves for Petroleum Industry. NEWMAN, HENDER & CO. LTD., Woodchester, Stroud, Glos. Bronze and cast-iron cocks and valves, cast-steel valves, "Christmas-tree" assemblies, crosses, chokes, flanges, forged-steel fittings and valves, and other components for use in the field or at refineries in the petroleum industry. Catalogue 101P of drawings, dimensions and characteristics, containing 174 pages and strongly bound for works use.

Transformers. HACKBRIDGE & HEWITTIC ELECTRIC CO. LTD., Walton-on-Thames, Surrey. Forced-cooled transformers up to the largest sizes and voltages; naturally cooled distribution transformers up to 1,000 kVA; small low-voltage transformers from 100 watts to 5 kVA. Details of construction, dimensions and output. Information regarding cooling arrangements and tap-changing equipment. Fully illustrated pamphlets.

Induction Heating. THE PHOENIX TELEPHONE & ELECTRICAL WORKS LTD., The Hyde, Hendon, London, N.W.9. The "Universal 10" is a self-contained 10 kW radio frequency induction heater for brazing, hardening, soldering or annealing. Water-cooled and suitable for operation from a three-phase supply. Illustrated leaflet.

Silicone-Based Paints. MIDLAND SILICONES LTD., 19 Upper Brook-street, London, W.1. Silicone-based paints are claimed to possess excellent thermal stability, coupled with resistance to weathering and atmospheric corrosion, thus providing a long-term saving in maintenance costs. Illustrated folder.

Lubrication Equipment. WAKEFIELD-DICK INDUSTRIAL OILS, LTD., Grosvenor-street, London, W.1. Illustrations of the range of lubrication equipment offered include installations for oil and grease lubrication, mobile dispensers, compressed-air line, locomotive and automobile lubrication. Brochure with over 50 photographic illustrations.

Crushers. ARMSTRONG WHITWORTH (METAL INDUSTRIES), LTD., Close Works, Gateshead-upon-Tyne, 8. "Kue-Ken" jaw and gyratory type crushers with feed openings up to 48 in. by 36 in. or bowls 36 in. in diameter. Illustrated leaflets numbers F 154 and F 155 respectively.

Steel De-Rusting and Passivation. THE WALTERISATION CO. LTD., Purley-way, Croydon. Description of the Deran treatments which remove rust and scale on steel articles and leave a passive, neutral and rust-inhibiting surface on the metal. Illustrated leaflet.

Light Alloy. HIGH DUTY ALLOYS LTD., Slough, Buckinghamshire. The alloy Hiduminium 100 is manufactured by powder metallurgy and is finally extruded into bars, sections and tubes, stamped in closed dies or rolled into sheets. Illustrated booklet of dimensions, properties and applications.

Spot-Welding Machines. SCIAKY ELECTRIC WELDING MACHINES LTD., Falmouth-road (Trading Estate), Slough, Buckinghamshire. All-purpose spot-welding machines ranging from 12 in. to 36 in. in throat depth and varying from 15 to 30 kVA. Illustrated catalogue.

Hand-Held Disc Grinder. LORANT & CO. LTD., 98-100 Croydon-road, London, S.E.20. Details of the "Suhner" electric disc grinder, with universal motor for alternating or direct current and various voltage ranges. The grinder takes discs of 7 in. or 9 in. diameter. Illustrated leaflet.

Chipping and Scaling Tools. CONSOLIDATED PNEUMATIC TOOL CO. LTD., Dawes-road, London, S.W.6. This brochure illustrates and describes a range of pneumatic tools for chipping, caulking, scaling, stone-working, and scraping. Information is also given on suitable chisels and other tools.

Aluminium-Sheathed Cable. W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., 95 Aldwych, London, W.C.2. Details of physical properties and chemical composition of aluminium for cable sheathing, and information on typical cables; installation methods. Illustrated brochure.

Cable Glands. THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD., Mercury House, Theobald's-road, London, W.C.1. "Telcon glands for thermoplastic cables" describes three ranges of terminating glands, with tables of dimensions. Illustrated leaflet.

Air-Break Switchgear. ENGLISH ELECTRIC CO. LTD., Queens House, Kingsway, London, W.C.2. Description of medium voltage switchgear type OB3, OB4 and OB5, for use on A.C. or D.C. systems up to 660 volts. Maximum current rating 6,000 amps. D.C. Illustrated brochure.

Induction Motors. LAURENCE, SCOTT & ELECTROMOTORS LTD., Openshaw, Manchester. Stock list of standard induction motors produced: squirrel cage, slip ring; screen protected, drip-proof, totally enclosed; n-s variable-speed motors. Leaflet.

Direct Current Amplifier. HILGER & WATTS LTD., 98 St. Pancras-way, Camden-road, London, N.W.1. Amplifier using galvanometer and photocell. Sensitivity variable by means of feedback control, giving 5mA output for inputs between 5 and 50 millivolt. Illustrated leaflet.

Radio Frequency Induction Heating. ENGLISH ELECTRIC CO. LTD., Kidsgrove, Stoke-on-Trent. Applications bulletin, part 1—an outline of the theory and capabilities of radio frequency heating with methods for approximate calculation. Illustrated brochure.

Fluorescent Lighting Fittings. HOLOPHANE LTD., Elverton-street, London, S.W.1. "Holoflux" fluorescent lighting system using optical louvres. Also "Lumiplex" plates for directing light downward. Illustrated leaflet.

Hand Lift Trucks. YALE AND TOWNE MANUFACTURING CO., Wednesfield, Wolverhampton. "Multi-Stroke" hand lift trucks; pallet and platform models; 3,500 to 5,000 lb. capacity. Fitted with hydraulic check to control load descent. Leaflet.

Welding Electrodes. THE ENGLISH ELECTRIC CO. LTD., Stafford. Stainless electrodes for welding austenitic stainless steels. Leaflet giving details of the electrodes and the physical properties of the welds obtained.

Crushing and Granulating Plant. HADFIELDS LTD., East Hecla Works, Sheffield 9. Single-toggle stone breakers and granulators. Specification, dimensions, sizes and weights, capacities, and lists of components and parts. Illustrated catalogue.

Arc-Welding Process. QUASI-ARC LTD., Bilston, Staffordshire. The Fusarc CO_2 process of automatic arc welding utilises a continuous covered electrode and a carbon dioxide gas shield. Technical catalogue describing the process.

Inert-Gas Generators. W. C. HOLMES & CO. LTD., Turnbridge, Huddersfield. Gas and oil-fired inert-gas generators for use in the petroleum, iron and steel, chemical and other industries. Illustrated catalogue.

Steel Sheets and Sections. DUNLOP AND RANKEN LTD., 147 The Headrow, Leeds 1. Steel rounds, squares, flats, sheets, angles, channels and other sections. Lists of sizes in stock.

Flexible Terminal Strip. PRECISION COMPONENTS (BARNET) LTD., 13 Byng-road, Barnet, Herts. The Kabi FLX5 flexible terminal strip for twelve-way 5/10 conductors. Illustrated leaflet.

THE FRENCH AIRCRAFT SCENE

(3) ENGINES

An unconventional exhibit at the 22nd Salon International de l'Aéronautique, to which reference has previously been made in ENGINEERING on June 7 (page 711) and June 14 (page 762), was the Atar Volant, France's "Flying Bedstead," shown on the static park by Société Nationale d'Étude et de Construction de Moteurs d'Aviation, 150 Boulevard Haussmann, Paris, 8. The Atar Volant is a vertical take-off and landing research craft—the forerunner of the coleopter (ENGINEERING, July 1, page 12, 1955), comprising an Atar turbojet adapted for vertical operation, surrounded by a cylindrical body housing the fuel and the stabilising system for maintaining vertical flight. Three versions of this machine are planned, of which two are already built. The C-400P1, which was the one displayed, is pilotless and remotely controlled, and has already done more than 250 tethered flights. The second machine, the C400P2, is fitted with an ejector seat; it has successfully completed tethered trials with a pilot on board, and has recently started free-flight trials. The third machine will be fitted with a complete cabin and a pivoting ejector seat. Finally, the coleopter itself—comprising a Zborowski annular wing surrounding the jet engine and firing a propulsive duct—may well be in the air before the 1959 Salon. All wind-tunnel tests on the annular wing are now complete, and a prototype machine is under construction, with a design speed of Mach 1·5. Later versions will employ the more powerful Atar 9 engine, and SNECMA expect to be able to develop very high speeds. The annular wing, it is claimed, is structurally very light, and can be made in heat-resisting steel without weight penalty.

The Atar Volant is the forerunner of the supersonic coleopter. SNECMA.

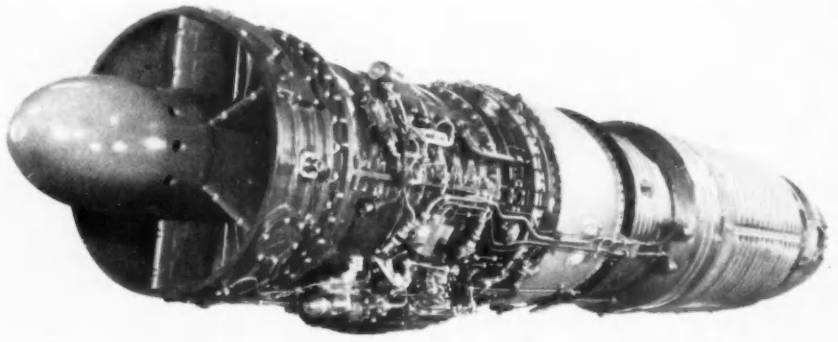
AERODYNAMIC JET DEFLECTION

The Atar Volant is controlled in flight by means of the aerodynamic jet-deflection principle developed by SNECMA. The exhaust nozzle of the Atar engine is divided into four sectors. Air bled from the compressor can be directed to any one of these sectors to spoil the flow pattern in that sector and thus produce an asymmetrical thrust in response to which the engine re-orientates itself. The control is automatically applied by gyroscopic stabilisers. (On the piloted version, the pilot's short control lever feeds signals to the stabilising system.) To compensate for rotational moments about the engine axis, air from the compressor was piped to suitably-disposed outlet nozzles mounted on two opposite undercarriage legs.

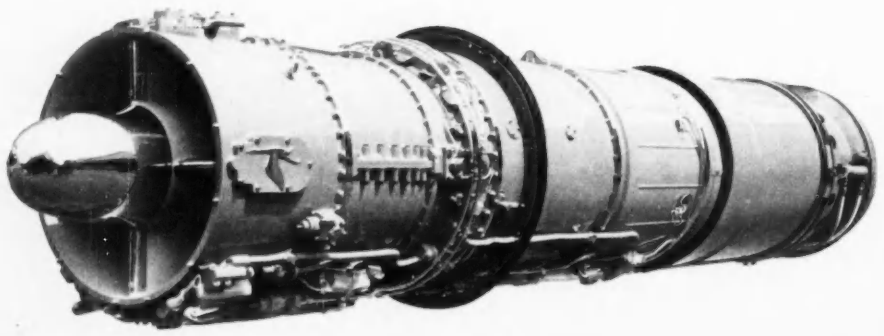
It may be recalled that SNECMA have applied the same principle of aerodynamic jet deflection to the design of thrust reversers (ENGINEERING, July 1, page 12, 1955), and to variable-area nozzle control. In the latter, the variable-area clamshell nozzles employed on standard Atar engines installed in a squadron of Mystère II fighters have been replaced by a fixed nozzle, the end of which is surrounded by a collector muff with slots communicating with the fixed nozzle. Air from the compressor is directed along a pipeline, through a butterfly control valve, to the collector muff, whence it is injected at a re-entrant angle uniformly around the exhaust pipe, causing the effective area of the exhaust jet to be reduced. The amount of air that is injected into the nozzle—and hence the effective area reduction—is controlled, through the butterfly valve, by the engine governor unit. This system extracts a penalty of about 1·5 per cent. in thrust at a considerable gain in mechanical simplicity—a point of importance as jet temperatures increase.

MEDIUM AND LIGHTWEIGHT TURBOJETS

Another SNECMA development on view for the first time at Le Bourget was the 13,200 lb. thrust Atar 9 turbojet, an afterburning version of the 9,700 lb. thrust Atar 8. This engine, which is to be installed in the Dassault Mirage III interceptor, has a weight/thrust ratio of 0·21. The Atar 8 and 9 engines have a nine-stage compressor, of greater mass-flow capacity than earlier Atar turbojets, an annular combustion chamber, and a two-stage turbine. The Atar 8 engine, destined for the Dassault Étendard IV, is now in pre-series production. Other engines in the Atar family—which power the majority of France's future front-line aircraft and her more powerful prototypes—under development include an all-steel version for high supersonic flight; and it is also of interest to note that SNECMA, like Hispano-Suiza, are taking an interest in nuclear power plants for aircraft and have formed an atomic energy division.



The Atar 9 turbojet with afterburner develops 13,200 lb. thrust. SNECMA.



The 3,300 lb. thrust HS804 turbojet, for high-supersonic lightweight interceptors. Hispano-Suiza.

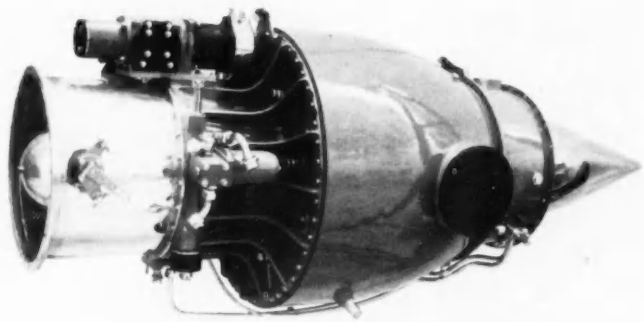
France now has an abundance of lightweight gas turbine engines. A recent entrant to this field is Société d'Exploitation des Matériels Hispano-Suiza, Rue du Capitaine Guynemar, Bois-Colombes, Seine. Their HS 804 turbojet (left) is specially designed for high-supersonic lightweight aircraft, and develops a maximum thrust of 3,300 lb. The weight/thrust ratio is 0·205 and the frontal area per lb. thrust is 0·0154. With an afterburner, the static thrust can be increased by 35 per cent. The engine has a seven-stage axial compressor and an annular combustion chamber with ten burners, and a single-stage axial turbine. The nozzle guide

vanes are hollow and air-cooled; the turbine blades are cooled at the root, and the disc is cooled on both faces, by air bled from the compressor. Ignition is by a high-energy system feeding two plugs on opposite sides of the combustion chamber.

Générale Aéronautique Marcel Dassault have also introduced a turbojet of this category—the 2,970 lb. thrust R.7, which has a weight/thrust ratio of 0·25 and a frontal area per lb. thrust of 0·0198 sq. in. per lb. This engine also has a seven-stage axial compressor, with a mass flow of 55 lb. per sec. and a pressure ratio of 3·8 to 1. The annular combustion chamber has 24 burners and 6 starting plugs, and the single-stage turbine is designed for an inlet temperature of 700 deg. C.

TURBOMÉCAS GALORE

The prolific gas-turbine clan designed and constructed by Turboméca, Bordes, Basse-Pyrenées, now comprises the following families: (1) *Pure turbojets*—the 350 lb. thrust Palas, the 550 lb. thrust Arbizon, the 880 lb. thrust Marboré II, the 1,540 lb. thrust Gourdon, and the 2,420 lb. thrust Gabiro; of these, the Marboré has been notably successful both in France and the United States, and the Gabiro has been fitted in many of the latest French prototype high-performance aircraft. (2) *Ducted fans*—the 705 lb. thrust Soulor, and the 840 lb. thrust Aspin II. (3) *Shaft turbines*—the " fixed " shaft Artouste II and III,



(Above) The ST450 recoverable ram-jet test vehicle for speeds up to Mach 3. SNCAN.

(Left) The Tramontane is the largest member of the Turboméca family of turbo-gas generators. (Capacity 5·1 lb. per sec., pressure ratio 3·5.) Turboméca.

developing 400 h.p. and 600 h.p. respectively, the former being particularly favoured for shaft-driven helicopters, as well as for driving water pumps; and the free-turbine Turmo I, II, and III, developing respectively 300 h.p., 360 h.p. and 750 h.p. The Turmo I is designed for ground applications and is the power plant of the Renault Étoile Filante, which holds the speed record for gas-turbine cars. The Turmo III is destined for use both as a helicopter shaft drive and as a propeller-turbine engine. (4) *Turbo-gas generators*—the Palouste IV, the Autan II and the Tramontane, with capacities of 2·5 lb., 2·8 lb. and 5·1 lb. per second and pressure ratios of 3·8, 5·1 and 3·5 respectively. The Palouste powers the cold-jet Djinn helicopter, and is also used in the J.P. volumetric displacement pump for the London Fire Brigade. It also powers the Bouhadon self-contained field air-conditioning unit, in conjunction with a heat exchanger and an expansion turbine. This unit has a cooling capacity of 119,000 B.Th.U. per hour and a heating capacity of 353,000 B.Th.U. per hour. (5) *Propeller turbines*—the 250 h.p. Astacon, the 400 h.p. Marcadan (an Artouste II with reduction gearbox), the 600 h.p. Artouste III and the 750 h.p. Bastan. The last of these may be used on the Max Holste Super Broussard 02 transport aircraft, and on the Sud Aviation Fonceur.

AFTERBURNING AND RAMJETS

An afterburner system for the Turboméca Gabiro turbojet has been developed by Société Nationale de Constructions Aéronautiques du Nord, 12 bis Avenue Bosquet, Paris 7, which, it is claimed, increases the thrust by 40 per cent., to 3,400 lb., with a specific fuel consumption of 2·25 lb. per lb. thrust per hour. Last year flight trials of a Gabiro with afterburner were completed on a Canberra flying testbed at altitudes up to 54,000 ft. The exhaust nozzle can either be fixed, in the case of aircraft that are not required to fly for longer periods with the afterburner out of action; or, where it is necessary for the aircraft to cruise economically without loss of thrust, a two-position variable-area nozzle can be fitted. This system comprises 12 retractable shutters operated by four electrically actuated jacks, synchronised mechanically. Light-up is achieved by injecting a supplementary fuel supply into the main engine combustion chamber, giving rise to a small localised flow of high-temperature gas which traverses the turbine and ignites the fuel in the afterburner chamber.

SNCAN have for the past seven years been experimenting with ramjets both for aircraft and missile propulsion. One of their exhibits at the Salon was their ST450 ram-jet test vehicle, which has been in operation since 1954 and is designed for exploring speeds from Mach 0·9 to Mach 3 at altitudes up to 65,000 ft. It is 17·75 in. in diameter and 186 in. long, weighs from 385 to 495 lb. and carries 77 lb. of fuel. The launching carriage, which is propelled by two booster rockets, weighs 725 to 880 lb. The carriage is catapulted from a ramp, and during the launching flight, the fuel injection valve of the ramjet is automatically opened and ignition is initiated. The ram jet is controlled in flight by covered control surfaces regulated by an automatic pilot. Fifteen seconds after extinction of the ramjet, the combustion chamber is automatically jettisoned releasing a braking parachute from the centre body—which houses the recording instruments, automatic control system, and fuel tanks. After a further 15 seconds, the braking parachute releases the main recovery chute enabling the entire centrebody to be recovered. This operation has been successfully carried out on many occasions.

NITRIC ACID FURALINE ROCKET

A rocket engine of the type being fitted to the Mirage III interceptor is the SEPR 661, specially designed for the aircraft by Société d'Étude de la Propulsion par Réaction, 37, Rue des Acacias, Paris 17. The engine uses 98 per cent. nitric acid as oxidant with furaline fuel. It has two double-walled combustion chambers developing respectively 3,300 lb. and 1,650 lb. thrust; the inner shell of the combustion chamber is cooled by circulating the oxidant through the space between the inner and outer walls. From the front end of the combustion-chamber jacket, the nitric acid is piped to a distributor where it is metered, as is also the furaline. From the distributor, oxidant and fuel enter the injector head whence they are injected into the combusion chamber as impinging jets.

The centrifugal pumps supplying nitric acid and furaline to the distributors are driven through a gearbox by a constant-speed turbine which itself is driven by the exhaust from a gas generator. The latter comprises a small combustion chamber into which furaline, nitric acid and water methanol mixture are injected—the latter to increase the mass flow and to lower the gas temperature so as not to impair the turbine life. Upstream of the main pumps, and adjacent to the tank valves, are jet pumps which ensure a positive pressure at the main pump inlets, preventing cavitation at altitude.

Briefly, when the pilot operates the starting control, an electric motor starts to drive three generator pumps feeding propellants to the gas generator. Pressure switches then open the valves admitting the propellants to the gas generator, and combustion occurs. The exhaust gases drive the turbine and when it comes up to speed, the turbine takes over the drive of the generator pumps and the electric motor is cut out. When the main pumps delivery reaches the operating pressure valve, pressure switches operate jacks actuating the valves of the distributor, and the propellants are injected into the main combustion chambers.

NITRIC ACID INHIBITOR

One of the big problems in successfully developing a rocket engine using strong nitric acid is corrosion. SEPR have found that corrosion-resistant alloys alone were unequal to the task; and no surface treatments could be found to give the required life. They have, nevertheless, overcome the problem—by developing an inhibitor which is added to the nitric acid. Known as Omnifos, it consists of a complex phosphate compound dissolved in a nitric medium. Omnifos has proved to be remarkably successful in protecting mild steels, low-alloy steels, stainless steels, and non-ferrous metals from attack by nitric acid. Thus, SEPR have found it possible to construct their rocket engines without resort to expensive alloys and treatments.

French aircraft industry is rapidly regaining the momentum lost during the second world war. For example, 35 Mystère IVA and Super-Mystère aircraft are coming off the line a month; output of Fouga Magisters will reach 12 per month by the end of the year, and Vautour production is working up to 9 per month. 11 Alouette, 10 Djinn helicopters, 10 Broussard light transports and 6 Noratlas are being delivered each month. As regards export figures, from a total of 1·025 million francs in 1950 (aircraft, engines and equipment), they have risen to 4·182 million francs in 1953 and to 7·014 million francs in 1956. This is still less than one-twelfth of Britain's aircraft exports, because the French industry is much smaller and they have had to start again from scratch after the war. However, with the increasing trend in Western continental Europe to pool aeronautical resources—in which France is taking a leading part—the British aircraft industry may, in a few years, encounter serious competition in world markets not only from the United States.

FRENCH ELECTRIC LOCOMOTIVE PERFORMANCE

The ability of the BB 12000 electric locomotives of the French Railways to start under heavy loads was demonstrated by adhesion trials which were carried out between Briey and Audun-le-Roman at the beginning of May. These locomotives are equipped with ignitrons, which convert the 50 cycle single-phase power, obtained from the public mains, to direct current for the traction motors. The aim of the tests was to obtain information regarding the contact between the wheels and sanded rails under a number of varying conditions.

During the first trial a train of 35 goods wagons and weighing 2,013 metric tonnes was started twice on an almost unbroken sequence of 1 in 100 gradients. The tractive effort at the draw bar at the first start was 37·4 metric tons and at the second start 34·2 metric tons.

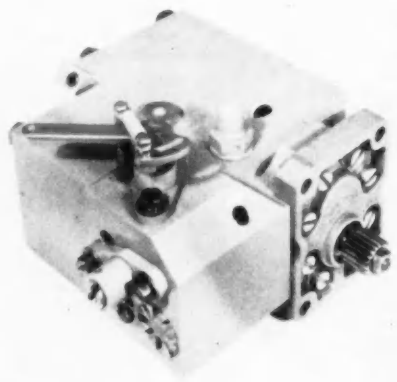
Recordings showed, however, that the limit of adhesion had not been reached and that the rate of acceleration, although low, could be reduced still further. A train comprising 40 wagons with a total weight of 2,120 metric tons was next successfully started, while later the load was raised to 2,223 metric tons with similar satisfactory results. During these trials the maximum tractive effort at the drawbar was 38 metric tons, which corresponds to about 40 metric tons at the wheel rims and to an overall coefficient of adhesion of 47 per cent. Oscillograph readings showed that this figure could not be exceeded without a small trace of slip, but, it is pointed out, this does not mean that 2,223 metric tons is the maximum load which could be started with these locomotives on a gradient of 1 in 100.

As regards acceleration it was found that an average of 3·2 cm. per second per second, or 6·5 km. per hour per minute was obtainable. This figure is common in normal service with direct-current motors but to reduce it to 1·2 cm. per sec. per sec., as is possible, results in an economy in effort of more than 1 kg. per metric ton; and this can be used to increase the load that can be started with the same total tractive effort at the wheels. This being so it was decided to carry out a test with a load comprising 54 wagons and weighing 2,424 metric tons. Two separate starts were made on a rising gradient of 1 in 100, during the second of which the maximum tractive effort varied from 38 metric tons at the start to 33·7 metric tons at 8·5 km. per hour, the acceleration being 2·2 cm. per sec. per sec. During these trials part of the train was on a curve. These results show that 50 cycle ignitron locomotives can be employed to start heavy trains owing to their mechanical design, a result which is due to the fact that their motors can be run at low speeds for prolonged periods and to their good adhesion. Their achievement is the more remarkable as the total weight is only 85 metric tons.

The BB 12000 class of locomotives employ ignitrons for current rectification. Number 12001, shown here, differs from the one tested only in gear ratio.

FUEL CONTROL UNIT FOR GAS-TURBINES

For use on small gas turbines, the Plessey Company, Limited, Ilford, Essex, have developed a complete self-contained fuel system. Weighing 8 lb., it comprises a fuel pump, governor by-pass valve, pressurising and relief valves and a shut-off cock, all built into the one unit. External connections are three in number, the inlet from the fuel tank and the delivery connections to the burners and igniter. The unit is suitable for use on engines from 200 to 1,000 b.h.p., with drive speeds between 3,000 and 6,000 r.p.m. and fuel pressures up to 800 lb. per sq. in. It can be built to give any desired governor characteristic. Acceleration is controlled by metering the fuel proportionally to the engine's speed. Maximum fuel pressure is controlled by a relief valve and, to prevent flame extinction following a sudden removal of load, a valve to prevent pressure falling below the necessary minimum value is also provided. The fuel control valves have no sliding parts. The speed setting is externally adjustable and a bleed from the servo chamber can be provided to allow the use of an overriding control.



This complete fuel control unit for gas-turbines weighs only 8 lb.

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SCOTTISH TELEVISION

The Independent Television Authority claim that their new transmitter which is being installed at Black Hill, Lanarkshire, will transmit the most powerful Band III signal in the world. The frequencies of operation are 199·7305 Mc/s for vision and 196·2395 Mc/s for sound. In the direction of Dundee the effective radiated power is 475 kW. About 3,310,000 people are within the primary service area.

FIRE ALARM

A fire alarm system that is completely independent of external supplies is being put on the market by Gent and Company, Limited, Faraday Works, Leicester. Basically, the "Blaze-larm" consists of a clockwork bell, which is released by a thermostat mounted in the base. As the bell rings, a red indicator protrudes from the side, and can only be replaced by re-winding the bell which is carried out by turning the gong. The thermostat is designed to operate at 125 deg. F. ± 3 deg., and re-sets on cooling. The detector unit can be hung on a wall or placed near a hearth, in fact, in any position where there is some possibility of fire danger. It measures 5¼ in. by 4½ in. and is 2¼ in. thick. Within the thermostat circuit is a pair of terminals from which a connection can be made to an extension bell that can be situated at some convenient position remote from the detector, possibly in a watchman's hut, and which is self-powered by dry batteries. The two units together offer a very neat fire alarm system.

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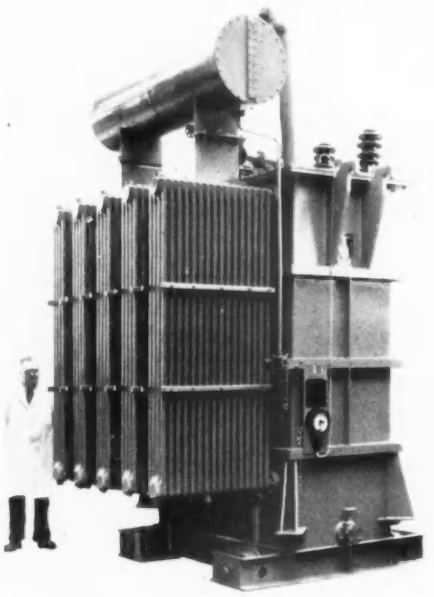
STAINLESS STEEL RADIATORS

The use of stainless steel pressings, welded by the argon arc process, has enabled the Washington Engineering Company, Limited, P.O. Box No. 4, Washington, Co. Durham, to produce a range of radiators which, it is claimed, are cheaper than pipe bundles and coils. The radiators, which are similar in appearance to the traditional pressed steel or cast-iron types, are available in 11 standard sizes, subdivided into 3 types, with 2, 3 or 5 columns, according to the width and surface required. They are made from pressings in 19 S.W.G. (0·044 in.) stainless steel, special attention having been paid to tool design to prevent distortion of the metal grain structure, and to the welding process to minimise the risk of weld decay. The radiators are suitable for hot water heating systems, especially in districts with corrosive water supplies, and for condensing, cooling or heating in the chemical and engineering industries.



A typical industrial use of the Washington pressed stainless steel radiator is on this 3,000 kVA transformer.

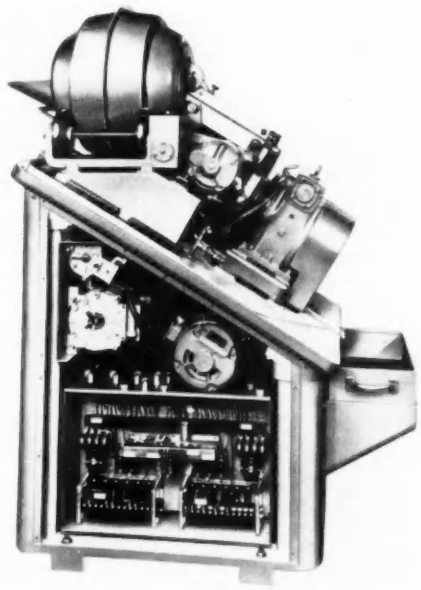


Fig. 1 Power for the motors driving the Roy screw slotting machine is derived from germanium rectifiers. Up to 720 pieces per minute can be machined, depending on the size and material of the blanks.

SCREW SLOTTING MACHINE

A machine for slotting the heads of screws at a rate greater than they can be upset, has been introduced by Roy Machinery and Sales Incorporated, New Britain-avenue, Farnington, Connecticut, and is being marketed in this country by Automation Limited, Devonshire House, Vicarage-crescent, London, S.W.11.

The machine is a development of one that has been on the market for a little while, and both speed and range have been extended. The principle of operation is that the screw blanks are fed on to a radially-grooved "dial" which revolves and carries them past a saw for cutting the slots. The blanks are then rotated against a serrated plate to remove any burrs, and are dropped into the collecting tray. A view of the machine showing the control mechanism is given in Fig. 1, and details of the cutting operation in Fig. 2.

Blanks are fed into the rotating barrel, which feeds them into a chute one at a time. At the head of the chute is a rotating star wheel which rejects any blank that has not fallen in the correct position. The blanks slide down the chute under the guidance of an overhead bar (to keep them spaced) and lodge in the grooves of the dial. The standard machine is fitted with a dial that has 72 slots on one side and 120 on the other, to cover the range of size from 8 B.A. to $\frac{5}{16}$ in. The dial can be reversed by removing the three Allen screws which hold it in place. The half horse-power motor rotates the dial at a chosen speed, and carries the blanks between the dial and a sprung plate. A blank with an oversized body causes the plate to move back and to actuate a microswitch which stops the machine. Two feelers carried on a bar projecting from the fixed head span the heads of the blanks, and any oversized head causes them to lift and thereby also actuate the microswitch. Any head that projects too far is detected by a third feeler placed just before the saw.

The saw is driven by a $\frac{3}{4}$ h.p. motor, and has a speed range from 200 to 600 r.p.m. so that the correct speed can be chosen for the material of the blanks being cut. The dial speed ranges from 0 to 6 r.p.m. The serrated plate which causes the blanks to rotate after the slots have been cut is fixed on the stationary head, and has a replaceable face. The blanks are sheared off against a cutting plate. During the rotation of the dial, streams of oil are played over it to remove all swarf, so that the slots are clean when they return to the top to receive the next blank. A separate motor rotates the feed drum, and has an expanding pulley on its shaft so that the rotation speed can be selected to suit the size of blank being used. The feed drum only rests on the drive rollers and can be lifted clear if required.

When setting up for a certain size of blank, the entire feed system can be moved by a lead screw clear of the dial plate, and for the final setting a fine adjustment is provided. Screwing the feed section clear also allows the changing of the dial plate to be carried out. The machine derives its power from germanium rectifiers mounted in the base, which feed the motors through the speed controllers. A three-phase supply of 220 volts is required for operation. The production rate of the machine is up to 720 pieces per minute, depending upon the size and the material. Screw lengths from $\frac{1}{4}$ in. to $2\frac{1}{2}$ in. can be accepted, including all types of head. Attachments are available to line-up hexagon heads in their correct position. A pin can be inserted in the feed line to stop the flow of blanks at any time. Saw and dial motions are interlocked to prevent the dial being rotated while the saw blade is stationary and so avoid possible damage. The tank for the cooling oil is contained in the base of the machine. The dimensions are 52 in. by 33 in. at the base, rising to 44 in. to the saw and 70 in. to the top of the hopper.

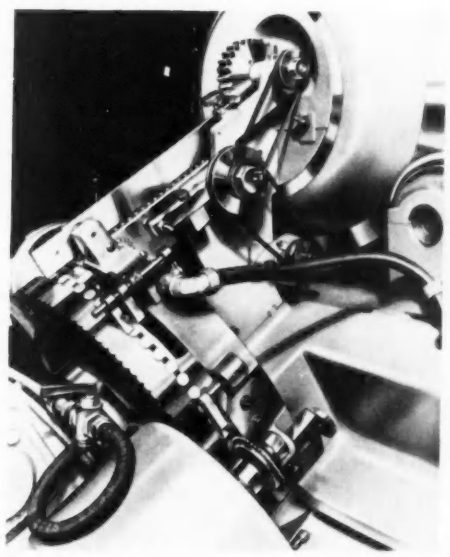


Fig. 2 A star wheel aligns the blanks in the feed chute, and they are subsequently checked for head size by two sets of feelers.

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MINIATURE CRUCIBLE FURNACE

The Morgan Crucible Company, Limited, Battersea Church-road, London, S.W.11, have introduced a miniature crucible furnace, which can be supplied for firing on paraffin, town gas or coke. Self-contained and simple to operate, the furnace is particularly suitable for schools and other teaching establishments, but it also has obvious applications in foundries or laboratories for carrying out small test melts.

When fired on paraffin the furnace is equipped with a self-contained burner and a welded steel pressure tank, which holds enough fuel for three or four melts. A long-stroke quick-acting hand pump enables the necessary pressure to be built up in the tank, a few strokes of the pump sufficing for a long period of operation. Typical performance figures, starting with a hot furnace, are: 10 lb. of aluminium melted in 15 minutes, or 32 lb. of copper melted in 50 minutes.

The gas-fired model is suitable for town gas at from 3 in. to 5 in. water gauge pressure. At 4 in. water gauge the gas consumption is 500 cub. ft. per hour, and with gas at 500 B.Th.U. per cub. ft., the furnace will melt 10 lb. of aluminium in 15 minutes or 32 lb. of copper in 35 minutes, both timings being from a hot start. Air is supplied to the furnace by an electric blower with a built-in universal motor, suitable for 110 volts, 200/220 volts, or 230/250 volts, alternating current (single phase), or direct current.

As adapted for coke firing the furnace is also power-blown, the electric blower being similar to that supplied with the gas-fired model. With good metallurgical coke of about 1 in. to $1\frac{1}{2}$ in., the furnace will melt, with a hot start, 7 lb. of aluminium in 15 minutes, or 20 lb. of copper in 30 minutes.

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ABSORBING REFLECTIONS

One of the problems of the communication engineer working at micro-wave frequencies is reflection. That is, reflection of waves at various parts of his equipment. Waves in the sea hitting a harbour wall demonstrate the effects of wave reflection. When a wave is reflected it goes back and hits incoming waves, making rough water and breakers. Much the same thing happens with electromagnetic waves in radio equipment. Interference between the incident wave and a reflected wave can cause dangerously high voltages, power loss, and wandering of signal frequency.

Clearly, the effects of wave reflection are to be avoided. The best way is to have no reflections. But this is impossible in all but the simplest situations. An alternative is to have a device which absorbs the reflected waves before they get too far. Such a device, called an isolator, must discriminate between the incident wave and the reflected wave; because the incident wave must not be absorbed. Above frequencies of 1,000 Mc/s, isolators have been made to work successfully. They exploit the Faraday effect and are small blocks of ferrite. Ferrites are dark heavy materials; they are strongly magnetic and bad conductors of electricity. In the latter respect they contrast with iron, which is strongly magnetic but a good conductor. The success with which isolators have been applied in a limited frequency band has lead to attempts to extend their range of application.

Studies at Harvard University suggest that garnets can extend the range of application of ferrities. Artificial garnets that have the same crystal structure as the gem stone have been chemically modified and appear capable of operating at frequencies as low as 100 Mc/s.

The behaviour of ferrities is explained in terms of the precession of orbital electrons in a magnetic field. When the micro-wave radiation enters the ferrite in one direction, its direction agrees with the direction of the precession of the electron. But a reflected wave travelling in the opposite direction is opposed by the electron precession. The time it takes to damp out the precession is important. The longer this time, the lower the frequency at which the isolator is effective. Some garnets have damping, or relaxation, times of 1 microsecond. Earlier ferrites had times of 0·01 microsecond.

Ferrites are produced from powdered mixtures that are compressed and fused at high temperatures. Bell Telephone Laboratories, New York, are working on new ferrite materials that can be made at a lower temperature. They are essentially magnesium, manganese, aluminium ferrites or nickel manganese ferrite with a small amount of copper replacing some of the magnesium or nickel. Copper increases the reactivity of the mixture and so decreases the firing temperature. A reduction of at least 100 deg. C. has been obtained. Under comparable conditions it is claimed that this results in lower porosity and improved uniformity of material.

ATOMIC REVIEW

Chain Reaction

NOTHING succeeds like success. Now that the Calder Hall nuclear power station has been working efficiently for nearly a year, the eyes of the World are opening to the merits of the gas-cooled graphite-moderated reactor system. Euratom, Japan, and now India, South Africa, Germany, Italy, Spain and Poland are planning to build reactors of this kind, and interest is spreading like a chain reaction. The main reasons for this choice are briefly as follows. The reactor uses natural uranium as fuel and so dispenses with the high costs involved in separating the fissile constituent; it employs a moderator which though efficient is comparatively cheap (heavy water, the main alternative where natural uranium is used, once more involves expensive separation processes) the conversion factor is quite high (an important consideration since countries contemplating reactor construction generally have an eye to the future when plutonium may be used as fuel enrichment); a negative temperature coefficient provides intrinsic safety; finally the successful working of the Calder Hall station and the decision in Britain to build base load stations of a similar kind does much to create confidence.

Pippa's Prospects

Speaking at the recent sectional meeting of the World Power Conference in Belgrade, Mr. J. A. Jukes, Economic Adviser to the United Kingdom Atomic Energy Authority said that there were circumstances in which gas-cooled reactors with a design electrical output as low as 20 MW could be operated economically, even using natural uranium fuel. His remarks were extended by Mr. S. A. Ghalib, chief engineer of the A.E.I.-John Thompson Nuclear Energy Company, who stated that the capital cost per installed kW of a 20 MW gas-cooled station burning natural uranium would be 2·2 times that for a corresponding 100 MW station, though with some enrichment this might be reduced to 1·5 times. He also discussed the safety of the gas-cooled graphite-moderated reactor referring to its negative temperature coefficient, and to the design principle whereby even in the extremely unlikely event of all gas circulators breaking down simultaneously, there would be adequate natural convection to prevent an undue temperature rise. By ensuring that the thermal centre of the heat exchangers was above that of the reactor, the transient temperature rise on breakdown could be limited to 100 deg. C. and a final steady temperature less than 50 deg. C. above normal operating temperature.

Mr. Ghalib said in addition that the nuclear power stations for the Central Electricity Authority were being built on the basis of guaranteed output, guaranteed completion date and fixed price, and that these would almost certainly be the conditions in which subsequent contracts, home or overseas, would be undertaken. He also remarked that operators trained on to-day's gas-cooled reactors would be capable of operating to-morrow's high-temperature stations. According to Mr. H. H. Gott of the U.K.A.E.A., operating such stations was no more difficult than for conventional plant, and staff of roughly the same quality and quantity would be required. He said that in the case of Calder Hall only three faulty fuel elements had been detected so far but there had been no significant contamination of the gas circuit. Radioactive emission from the coolant circuit—due to irradiation within the reactor—had been higher than expected but this represented no problem. He mentioned, too, the problem of transporting irradiated fuel: a load of only one ton was carried in a container weighing between 25 and 50 tons.

Dr. H. S. Arms, chief engineer of the atomic power group comprising the English Electric Company, Babcock and Wilcox, and Taylor Woodrow, said that capital costs would fall not only as the size of stations increased and technology advanced, but also as the skill and experience of erection staffs improved. Also, though only 20 per cent. of the volume of the plant was occupied by the reactor core in one C.E.A. design this could be bettered. In addition a much simpler form of control rod had been designed. He also emphasised that educational and power programmes could not be mixed. Mr. J. W. Ashley, chief engineer of the fifth group, Atomic Power Constructions Limited, also speaking on station costs, remarked that the marginal difference in power costs between stations based on different tried reactor systems would probably be no greater than between good and bad engineering applied to a single reactor system. He also expressed the view that mixed stations using a combination of conventional and nuclear fuels were a doubtful proposition even with large stations.

Gas-Cooled Reactors Abroad

The intention of the Japanese and Euratom to build gas-cooled reactor power stations is already well known, but recently certain other countries have expressed similar aims. Dr. Homi J. Bhabha, chairman of the Indian Atomic Energy Commission, at the sectional meeting of the World Power Conference spoke of three locations in India: Ahmadabad, Bombay and Delhi, where Calder Hall type power stations could be economically operated, and a decision on these projects is to be undertaken shortly. India is also investigating small gas-cooled power reactors of 20 to 50 MW using beryllium oxide as moderator and natural or slightly enriched uranium as fuel. A feasibility study on a reactor of this kind having an output of less than 30 MW is in progress at Trombay.

In his paper presented at the meeting, Ing. Jose Antonio Lopez-Rua stated that the gas-cooled graphite moderated reactor was one of the designs under consideration by the Grupo de Estudio de Reactores of the Spanish Atomic Energy Commission and that the existence of local uranium ores made a natural-uranium system attractive. Probably the first (demonstration) reactor to be built would be a small unit (20 MW) using a heavy-water moderator, since it was necessary to keep capital costs low, but the estimated rate of increase in installed nuclear capacity in Spain by 1970 was likely to be some 350 MW annually, giving better scope for the graphite-moderated gas-cooled system. Another report states that Spain plans to have two 200 MW nuclear stations operating by 1970, 20 by 1980, 71 by 1990 and 194 by 2000, though this seems rather far to plan ahead at present.

The Italian Government is also reported to be contemplating purchase of a nuclear power station from Britain and Signor Mattei, president of the State Corporation Ente Nazionale Idrocarburi (E.N.I.) has recently had talks at Harwell and with the General Electric Company. A campaign for construction of a Calder Hall type of station is said to have been organised by the Cape Chamber of Industries in South Africa. Dr. A. J. A. Roux, research and planning director of the South African Government-financed Atomic Energy Board, is expected to visit Britain, the Continent, the United States and Canada in the near future. Germany, too, is believed to be considering the purchase of a gas-cooled reactor from Britain.

Poland also has clearly been impressed with the gas-cooled design, in spite of Soviet interest in water-cooled reactors, and is to have one natural-uranium reactor based on this design by 1965.

Gas-Cooled Reactors at Home

The station proposed for Inkley Point in Somerset, which is likely to be built by the group associated with the English Electric Company, will probably be of 500 MW electrical capacity. It should be emphasised that the proposed design differs from the more conservative version previously submitted to the C.E.A.

Two more sites are reported to be under investigation for 500 MW stations in Britain—at Blaenau Festiniog in Merioneth near the pumped-storage scheme previously discussed in Atomic Review (April 5), and at Dungeness in Kent. Borings have been made but this does not of course indicate a final decision.

Cost of Using Enriched Fuels

Speaking at the Belgrade meeting, Dr. Bhabha gave reasons for India's choice of a natural-uranium reactor, and referred in particular to the cost of enriched fuels. For an installed nuclear capacity of 1,000 MW operating at high load factor, using enriched uranium at a cost of 15 dols. per gram of uranium 235, fuel costs alone would amount to some 22 million dols. a year; and this was a running financial commitment. Depending on burn-up, corresponding costs for natural uranium might be half that figure. There was, too, the further consideration that countries without their own diffusion plants or other means of separating the uranium isotopes, would be anxious to accumulate stocks of derived fissile materials (in this case plutonium) and so preferred to build plants with high conversion factors as was the case with the gas-cooled graphite-moderated system. We hope to give further details of India's atomic energy programme in a subsequent Atomic Review, including recent news of uranium and thorium ore deposits found there.

Reactors in General

MTR and Friends

Reactors are classified in many ways but the experimental reactors are the most confusing. In Britain and America terms like reactor test, reactor experiment, research reactors, critical and experimental facilities and zero-energy reactors are used with considerable freedom, and it is difficult to distinguish between low-power and small-scale prototype systems and reactors designed simply for criticality and other investigations. However, the materials testing reactor (MTR) is clearly defined by its name, and though the Soviet beryllium-moderated reactor discussed in Atomic Review on June 7 could loosely be described as an MTR, we were mistaken in doing so, for it is in fact a critical facility designed primarily for core experiments. A materials testing reactor has a high flux and is equipped with experimental holes and recesses in which items can be inserted for irradiation studies.

Soviet 420 MW Power Station

At the recent sectional meeting of the World Power Conference, Dr. S. Skortstov, of the Institute of Atomic Energy of the Soviet Academy of Sciences, gave details of a nuclear power station to be built in the European part of the Soviet Union. It should be emphasised that the accuracy of the figures quoted below cannot be guaranteed since they are based on a rapidly read verbal statement in Russian, though some effort has been made to check their consistency. The station will be of 420 MW electrical capacity and will include two reactors each with a thermal output of 760 MW, representing an overall efficiency of 27·5 per cent. The reactors will presumably be cooled and moderated by pressurised light water so that some enrichment is necessary, though other systems using graphite or heavy water moderators are under consideration. The fuel will be uranium oxide (UO_2), with an initial load of 17 tons of natural uranium oxide and a subsequent load of 23 tons at 1·5 per cent. enrichment, making 40 tons i ll. The core will comprise a basket containing 349 hexagonal zirconium containers arranged in a triangular lattice of 147 mm. pitch. The containers, which will be 3·2 metres in length,

will enclose fuel rods 2·2 metres long and 14·3 mm. in diameter. On this basis the number of fuel rods per hexagonal container would be seven, which gives a total fuel mass of the same order as the figure already named. The choice of a triangular lattice does not necessarily imply a triangular core, which would appear to offer a poor flux distribution. It should be noted, however, that a hexagonal honeycomb is compatible with an isosceles triangular boundary and the apices might possibly comprise breeding elements; but a star or hexagon core would obviously be superior from a nuclear point of view, making a triangular core shape extremely unlikely.

The water pressure in the reactor core is to be 100 atmospheres (1,470 lb. per sq. in.) and the reactor water outlet temperature 275 deg. C. with a return temperature of 250 deg. C., giving a temperature rise of 25 deg. C. There will be six coolant circuits per reactor each with its associated heat exchanger or steam generator, together with water-purification plant; and provision is made for isolating each of the loops. A total of six 70 MW two-stage turbo-generator sets will be installed, and the steam pressure will be 32 atmospheres (470 lb. per sq. in.). Some 7·45 per cent. of the gross electrical output will be used for internal services. It is of interest that the values given here both for steam conditions and core dimensions correspond closely to those for the largest of the four American pressurised water reactors referred to in the following paragraph.

Four United States Pressurised-Water Reactors

In a paper (" Design of Nuclear Power Plants for Underdeveloped Countries ") presented at the same meeting, Dr. W. E. Shoupp, technical director, and Mr. A. R. Jones, application engineer, both of the Westinghouse Electric Corporation, stated that their company had adopted four ratings of pressurised-water reactor which they believed offered good prospects for commercial power generation in certain areas. These units are of 11·5 MW, 15 MW, 68 MW and 143 MW gross electrical output. All are of familiar American pressurised-water design operating at a water pressure of 2,000 lb. per sq. in. and the reactor cores and fuel elements are all basically as described in a subsequent note. For the smallest station, the heat output is 43 MW, steam pressure 520 lb. per sq. in. and the reactor inlet and outlet temperatures 492 deg. F. (256 deg. C.) and 518 deg. F. (270 deg. C.), with a flow of 5×10^6 lb. of water per hour. For the 143 MW plant (net output 134 MW and heat output 492 MW), steam is produced at 500 lb. per sq. in.; reactor inlet and outlet temperatures are 487 deg. F. (253 deg. C.) and 525 deg. F. (274 deg. C.); and the flow is 37×10^6 lb. per hour.

For the 143 MW model, the fuel is similarly arranged, with 305 pelletised fuel rods per element assembly and 76 assemblies in the core. The core contains 24,400 kg. of uranium with an approximate enrichment of 2·6 per cent. and has calculated reactive life of 10,000 hours. The fuel rods are 117 in. long with a fuel bearing section of 102 in. and a total number of 23,218 are used in the reactor. As before, the pellets are 0·30 in. in diameter but the containing tubes are of stainless steel with an outside diameter of 0·335 in.

Pellet Fuel for PWR

The fuel for the Westinghouse 11·5 MW reactor, referred to above, is uranium oxide (UO_2) clad with a zirconium alloy. The oxide is compressed into small cylindrical pellets and then sintered. The pellets have a diameter of 0·30 in. and are loaded into zirconium tubes having an outside diameter of 0·36 in. Zirconium end plugs are welded into the tubes, which completely isolates the UO_2 from the primary coolant. Each rod is 17 in. in length and a total of 12,240 are used in the reactor.

Approximately 127 fuel rods are assembled in a square lattice between zirconium end plates to form a fuel bundle. Holes in the end

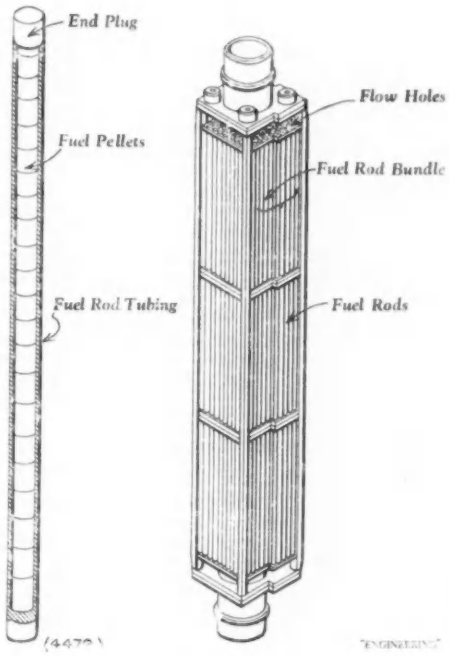


Fig. 1 The series of four pressurised-water reactors marketed by the Westinghouse Electric Corporation employ a pelletised uranium oxide fuel contained in tubes arranged in bundles to allow passage of coolant.

plates permit the flow of coolant between and parallel with the fuel rods. Three fuel bundles are used in series in a fuel assembly (Fig. 1), with a total of 32 fuel assemblies in the core. The core has an active heat transfer area of some 1,500 sq. ft., an average diameter of 34 in. and an active height of 50 in. The core loading is approximately 2,000 kg. of uranium having an enrichment of less than 14 per cent. The core is designed for a calculated reactivity life of 7,000 hours.

The reactor is controlled by means of twelve control rods the material for which has not been selected; but Haynes-25 and silver cadmium are being studied. The control rods will be positioned automatically to maintain the average coolant temperature at 505 deg. F. The control rod drive mechanisms are located on the reactor vessel head, and are hermetically sealed units. The basic element of the mechanism is a canned synchronous reluctance motor. The control rods are held in a fixed position by applying direct current to the mechanisms, and are moved up or down by applying low-frequency alternating current. Fast rod insertion is accomplished by disconnecting the rod from the drive mechanism.

Control Rod Flux Peaking

The last major fabrication problem in commissioning the American Army Package Power Reactor (APPR), discussed fully in Atomic Review on May 10, was encountered, in a sense, after the reactor started to operate. In the zero-power experiments run at Schenectady on the first core loading, a detailed and careful flux check of the entire core was obtained. In the course of this mapping, it was determined that a bad flux peak occurred in the upper end of the fuel portion of the control rods. Since the rods are one of the most important coolant flow control points in the core, the flux peaking indicated a high probability of boiling during normal operation. These details were given in a paper presented by Mr. K. Kasschau, atomic energy manager for Alco Products Incorporated, on June 10.

The flux peaking was attributed to the existence of the large water hole immediately above the top of the fuel portion as seen in Figure 2. Neutrons generated in the fuel portion, and in adjacent fuel elements, are slowed to thermal levels in the water. It is characteristic of this situation that the flux level increases above the surrounding areas owing to the fact that the low absorption of water in the region reduces their absorption rate. But the uranium which is adjacent to this region (in this case at the top of the fuel) is subjected to a high flux and, therefore, has a high fission rate and a high heat rate.

The cure for the problem was to reduce the peaking by introducing additional absorbing material at the top of the fuel plates, to depress the flux in this particular region. As the illustration shows, this was accomplished by inserting combs in the top of the fuel and brazing them into position. These combs had to have a high cross-section for neutrons, be corrosion resistant and have reasonable structural strength. The final choice was Haynes-25 Alloy.

More Reactor Costs

Revised cost estimates for the experimental reactors in the U.S.A.E.C.'s five-year programme show increases similar to those recently announced for the power reactor projects (see. Atomic Review, May 17). The latest figures and construction schedules are as follows:

Experimental Boiling Water Reactor (EBWR). —Reactor fabrication costs were 3·9 million

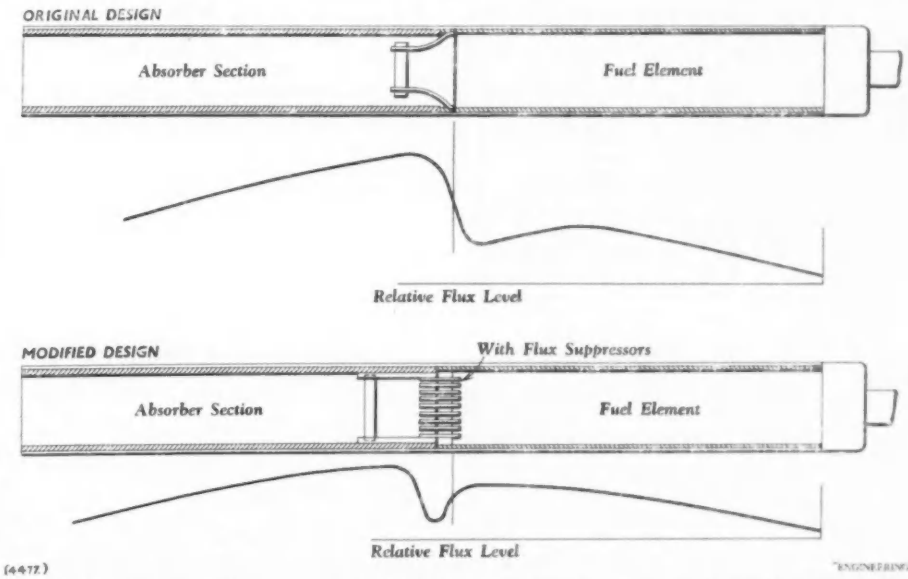


Fig. 2 A problem encountered in commissioning the American Army Package Power Reactor was flux peaking. The solution adopted was to introduce additional absorbing material at the top of the fuel plates.

dols. compared with an original estimate of 2·6 million dols., and fuel fabrication costs 1·2 million dols. instead of 0·9 million dols. Building and supporting costs remained at 1 million dols., making a total of 6·1 million dols. compared with the anticipated 4·5 million dols. The reactor began operation on schedule in December last year (see Atomic Review, February 1 and May 17, 1957).

Homogeneous Reactor Experiment (HRE-2).—Reactor fabrication costs have risen from 1·8 to 3 million dols.; building and supporting facilities remain at 630,000 dols. HRE-2 was originally scheduled for initial low power operation in June, 1956, but microscopic cracking in the leak detector system delayed start-up and the reactor is not now expected to go critical until December, 1957.

Sodium Reactor Experiment (SRE).—Reactor fabrication costs up from 3·5 to 6·8 million dols., fuel fabrication costs from 220,000 to 230,000 dols., and buildings and supporting facilities costs from 0·5 to 0·92 million dols. Originally scheduled for operation in June, 1956, the reactor went critical for the first time on April 25, 1957 (see Atomic Review, May 17).

Experimental Breeder Reactor (EBR-2).—The total cost is now estimated at 29·1 million dols., compared with an original estimate of 15·5 million dols. Initial operation has been postponed from March, 1958, to June, 1959.

Third Homogeneous Reactor Experiment

The homogeneous reactor HRE-2, now expected to go into operation in December, will have an enriched uranium fuel solution of UO_2SO_4 in heavy water and a heavy-water reflector. It was originally planned to replace

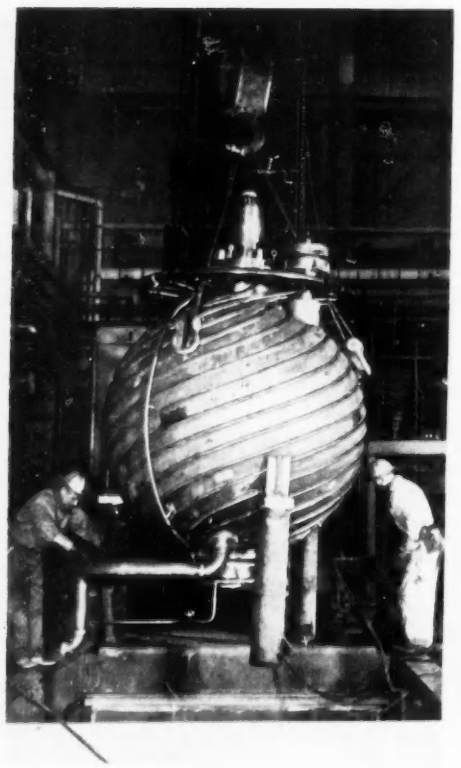


Fig. 3 Reactor vessel for homogeneous reactor experiment being installed at Oak Ridge, where it has been tested by Union Carbide engineers.

the heavy-water reflector, after a trial period, by a slurry blanket. This no longer appears feasible and a third reactor experiment, HRE-3, using a thorium-oxide slurry blanket, is being considered. HRE-2 is situated at Oak Ridge National Laboratory, which is operated by the Union Carbide Nuclear Company of the Union Carbide and Carbon Corporation under contract to the A.E.C. Fig. 3 shows the reactor vessel.

Aqueous Homogeneous Reactor

The U.S.A.E.C. has authorised the North Carolina State College to modify and operate its aqueous homogeneous research reactor. This reactor, which uses uranyl sulphate as fuel, first operated in September, 1953, but had to be shut down in June, 1955, after leaks had developed in the core tank. The modified version uses almost all the facilities of the original reactor except the core, but the maximum power level is reduced from 10,000 watts to 500 watts. This is only an interim measure to allow immediate operation of the reactor for training students, and the college hopes later to reconstruct the reactor for operation at 10,000 watts or more. The leaks which developed in the core tank were ascribed to an abnormally high chloride-ion concentration in the fuel solution. Precautions for preventing corrosion, especially that due to chloride ions, have been incorporated in the modified design.

Reactor Control System

An automatic control system has been devised for a reactor, utilising an ionisation chamber, an optical galvanometer and several photoelectric cells. The power level of the reactor is reflected in the neutron density. The ionisation chamber measures this density and the output signal is fed to a galvanometer which registers the signal as angular displacement of an attached mirror. A light beam is reflected from this mirror to one of several photoelectric cells which activate the control rods in a manner appropriate to the operational level of the reactor, resulting in a simple accurate method of keeping the power level within pre-set limits. (U.S. Patent No. 2,779,728: W. H. Zinn and Thomas Brill.)

Reactor Safety Device

A device has been proposed which is designed to inject neutron absorbing balls of cadmium or boron into a reactor in the event of a rise in power level above a predetermined limit. Since safety-rod systems tend to be slow or possibly inoperative during an emergency, it is desirable to have a means for positively injecting a neutron-absorbing substance independent of the safety or control rods. The suggested method comprises a passageway through the reactor, an exit for removing the balls after the emergency and a wheel adjacent to the reactor continuously revolving at high speed, with such balls carried round on the periphery. When the power level of the reactor increases sufficiently, a sensing element opens a gate in the casing surrounding the wheel and the balls are propelled through the gate into the core passageway by centrifugal force, thus inhibiting the reactivity factor without permanently poisoning the reactor. (U.S. Patent No. 2,773,823: John J. Gott.)

Heavy-Water Reactor for Italy

The U.S.A.E.C. proposes to issue a licence to ACF Industries for the export to Italy of a 5,000 kW (thermal) tank-type, heavy water moderated and cooled research reactor using 20 per cent. enriched uranium as fuel. Components of the reactor will be shipped to the Italian National Committee for Nuclear Research starting in the near future and continuing for about 12 months. The total value of the shipment is given as 1,246,000 dols.

Notes

Civil

The civil engineering contractors, Richard Costain, Limited, 111 Westminster Bridge-road, London, S.E.1, are planning to enter the nuclear field.

Course on Auto-Radiography

A five-day course on auto-radiographic techniques, of particular interest to biologists, will be held at the Isotope School, Atomic Energy Research Establishment, Harwell, from July 22 to 26. During the course lectures and demonstrations will be given to cover the basic principles of auto-radiography and the interpretation of the results obtained. Demonstrations on stripping film and coating and squashing techniques will be followed by practical work on squash preparations for auto-radiography and on the processing and staining of auto-radiographs, using normal and phase contrast microscopes. The course has been arranged in co-operation with Dr. S. R. Pelck of King's College, London, who will give most of the lectures and demonstrations. Application forms for the limited number of places available on the course should be sent to the Isotope School as soon as possible. Accommodation can be arranged locally by the School on request. The course fee of £10 does not include the cost of accommodation. Application forms and more detailed information can be obtained directly from the Isotope School, A.E.R.E., Harwell, near Didcot, Berkshire.

Conferences

The closing date for submission of titles and summaries of papers proposed by potential participants in the Conference on Radioisotopes to be held in the Paris Faculty of Medicine from September 9 to 20, under the auspices of Unesco, was originally May 1, but has now been postponed to meet requests of countries wishing to participate. Complete texts of papers should be sent to reach Unesco in Paris by July 1, to allow time for reproduction before the opening of the conference.

The tentative theme of a congress to be held from March 17 to 21, 1958, in Chicago, U.S.A., is " Industrialising the Atom." It will be known as the 1958 Nuclear Congress and sessions have been proposed on the following topics: 1, high temperature operation instrumentation; 2, monitoring and health instrumentation; 3, system control instrumentation; 4, process (non-nuclear) instrumentation for power reactors; and 5, safety and start-up control instrumentation.

Metals for Nuclear Power

The British Non-Ferrous Metals Research Association has begun a programme of research on metallurgical problems arising from the generation of power from nuclear sources. Announcing this at the Association's annual general meeting in Birmingham on April 24, the chairman of Council, Dr. Maurice Cook (chairman of the Metals Division of Imperial Chemical Industries) said that as a first step, with the co-operation of the nuclear power consortia and the Atomic Energy Authority, work was already in progress on the metallurgical properties of thorium and thorium alloys. The steady expansion of the work of the Association calls for much new equipment and consequently for more space, and a new laboratory block is to be erected adjacent to the present premises in Euston-street, London. Full details of the Association's work are given in the Thirty-Seventh Annual Report, which is available on application.

X-Ray Machine

The United States Naval Magazine at Port Chicago, California, is to use a 2 MV X-ray machine to test reactor castings for nuclear propelled vessels.

Films of British Atomic Energy Work

A series of films called " British Atomic News " in Eastmancolour dealing with the products of British firms in the field of atomic energy for peaceful uses are being made by a London company for exhibition throughout the world. Filming of the first production has been completed. The scheme was launched last year by Mr. B. Charles-Dean, managing director of Hartley-Ward Films Limited with the full knowledge of the United Kingdom Atomic Energy Authority and the Board of Trade. B.A.N. films are not confined to large-scale subjects like the construction of power stations, but cover in addition products and equipment used in nuclear reactors and the rapidly expanding uses to which radioactive isotopes are being put in the United Kingdom. Wherever a film is shown, the commentary will be the language of the country.

INTERNATIONAL CONGRESS ON COMBUSTION ENGINES

1—AN ENGINE WITH SYMMETRICAL STRESSING

This year the International Congress of Combustion Engines are holding their conference in Zürich from June 17 to June 22. During that time some 26 papers are being presented for discussion, and visits to works in the neighbourhood were arranged.

The papers presented covered most of the field of internal combustion engines, though the majority of them, 14 in fact, dealt with supercharging in some form or another. Other papers covered gas turbines, free piston engines and the development of a new type of valve gear for a four-stroke engine. In the present article a description of this engine will be given, and later extracts from three papers by Japanese authors will be set out to show some unusual developments in internal combustion engines that have been made in the Far East.

In addition to those papers that dealt mainly with the mechanical side of the engines, were two papers on what might be called the physical and chemical section, one of which dealt with the distribution of heat flow, and the other with the analysis of the combustion process.

An internal combustion engine valve system specially built for pressure charging and scavenging when using a four-stroke cycle was described by Dr. Alfred J. Buchi. He called it the Telescope or Concentric Valve System, and it consists basically, as the name implies, of concentrically arranged inlet and exhaust valves mounted centrally in the cylinder head of the engine. A central space is hollowed out of the crown of the piston to allow ample flow areas for the incoming charge and the outgoing gases. When the piston is in its top dead centre position, the shape of the combustion chamber formed between the piston and the head is a relatively deep disc of a smaller diameter than the cylinder bore. The provision of the hollow in the piston crown makes a circumferential wall around the combustion chamber, which facilitates the directing of the intake air and of the scavenging air flowing from the inlet valve opening to the exhaust valve.

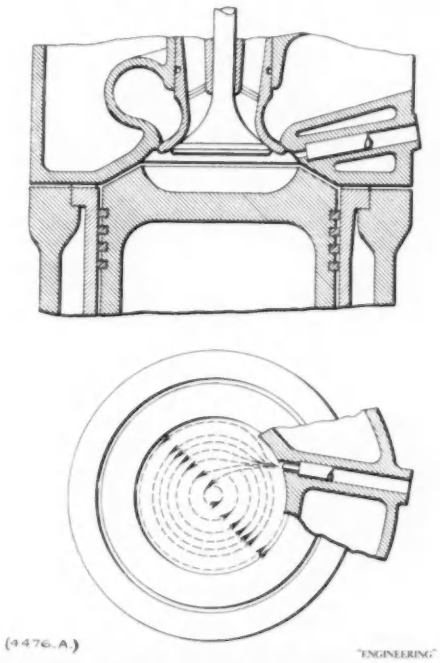


Fig. 1 Concentric valves allow a simple design of cylinder head for a four-stroke engine, giving large gas passages and completely symmetrical thermal and mechanical loading.

It should be explained that either the centre valve or the annular valve can be used as the inlet or the exhaust as desired by the designer.

A drawing of the head and combustion chamber with the valves closed is given in Fig. 1, which also shows the position of the injector, and with the valves open as they would be in the scavenging position in Fig. 2. The valves themselves are shown in Fig. 3. The combustion chamber may be so designed, and the cylinder head on its inner side so shaped, that when the piston is in the upper dead centre position, with both valves open, the inner valve disc extends into the piston crown, and a passage similar to an annular space is formed between the valve disc and the adjacent walls of the combustion chamber. The general shape is such that the inlet air can sweep through the whole space to give the best possible scavenging. The valve bodies, the inner wall of the reduced combustion chamber, and the surface of the piston crown entering this chamber, may be given such a shape that with both valves open, a smooth passage for the scavenging air is formed with approximately constant stream areas throughout. The movement of the scavenging air can be regulated by choosing the shape of the combustion chamber and of the hollow in the piston crown.

As mentioned earlier, the charge can be admitted either around the outer valve, and the discharge through the inner annular space between the valves or vice versa. Moreover, a rotary movement can be imparted to the charge by means of a spiral entrance surface, or separate guides, so that swirl is set up within the chamber. One of the particular claims for this arrangement is that economy in space is obtained. Also, more efficient scavenging can be achieved, which is uniform all round the combustion chamber. All parts are therefore positively swept without leaving any dead spaces. Equal cooling of the walls is also obtained.

One of the features inherent in the design is that the cylinder head and the piston crown surrounding the combustion space are absolutely symmetrical to the cylinder axis and present a minimum area of surfaces which are relatively plain and regular. No cuts or guides are necessary in the piston crown or in the cylinder liner, nor are masks required on the valves to direct the flow. The fuel injector is positioned in relation to the axis of the combustion space, so that the injected fuel arrives uniformly distributed and joins the swirling motion already present. Only one injection nozzle, (certainly for smaller engines), is required to distribute the fuel particles equally through the rotating volume of heated air.

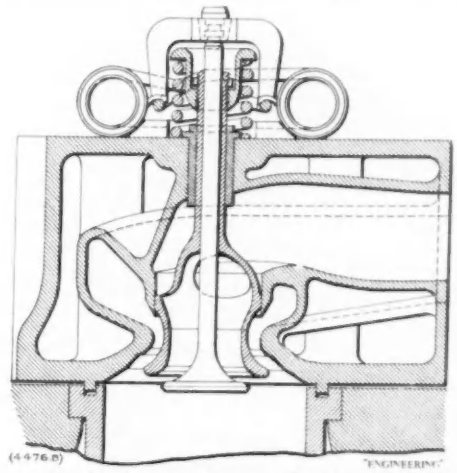


Fig. 2 Good scavenging can be obtained with both valves open and a spiral-form inlet duct provides initial swirl.

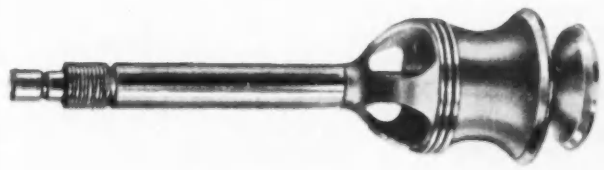


Fig. 3 Either passageway can be used for air inlet as desired, but it is important that the inside of the bell should be smooth.

CONCENTRIC VALVES

A spiral form duct leads to the inlet valve seat and a certain degree of swirl is therefore initially imparted to the air on entry. Apertures in the inlet valve body and the inlet duct provide air charge and exhaust passages. When the outer of the two concentric valves is used for the inlet, and the inner valve for the exhaust, the exhaust gases have to pass through the section between the two valves. In order that they may pass through this rather narrow passage with a minimum of pressure and heat loss, it is preferable to shape the inlet valve body into the form of a bell, containing no restricting ribs or the like in its narrowest part, so that the gases can pass freely through the apertures provided in the upper part of the bell-shaped wall to an exhaust duct in the cylinder head. This arrangement can be seen in Fig. 2. A spring plate and a helical spring can be used closing the outer bell-shaped valve, and a similar spring or a double hairpin spring operating on the valve through a common yoke can serve for closing the inner exhaust valve. Again this arrangement is shown in Fig. 2.

The surface of the combustion space is kept to a minimum which ensures that at the end of the compression stroke a high air temperature is achieved. Fig. 4 shows the comparison of the ratios of the surface of the combustion space to the swept cylinder volume for three different internal combustion engine types.

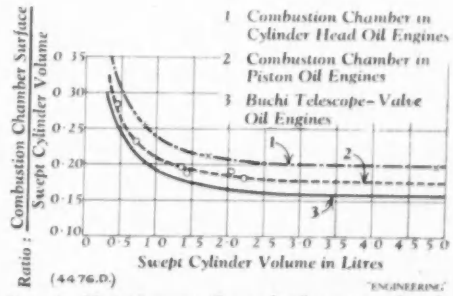


Fig. 4 Heat lost at the end of compression is proportional to the surface area of the combustion space. The ratio of combustion chamber surface to swept cylinder volume, plotted as a function of the swept volume, represents the reduction inh eat loss obtained by the concentric valve system.

For this comparison the surface of the combustion space is calculated with the piston about 15 deg. crank angle before upper dead centre which approximately corresponds to the ignition point of the engines. The ratios are plotted as a function of the swept cylinder volumes.

For an engine with a swept volume of about 1½ litres, the ratio is approximately 24 per cent.

larger in engines with a Comet type head than in a telescope valve type. The ratio increases as the swept volume increases, reaching approximately 26 per cent. for a 5 litre engine. The total loss of heat to the piston, cylinder head and the cylinder liner walls, which is nearly proportional to the surface area, is therefore considerably smaller in the telescope valve engine than in the comet head type. It is also smaller than the direct injection engine, though the difference at 5 litres is only approximately 11 per cent. This implies that the heat carried away by the water or air cooling system will be proportionately less, and the fuel consumption will be improved. Starting has been found to be much easier, and takes place with practically no noise from combustion knocks.

The great advantage both mechanically and thermally, is the symmetrical form which this valve arrangement allows. All operations with respect to suction, compression, combustion, expansion and exhaust occur concentrically and uniformly round the cylinder and valve axis. The mechanical stresses are thus evenly distributed, and so are the thermal forces. Unequal expansion of parts of the head due to temperature differences across it are eliminated, which is completely different to the conventional four-stroke cycle engine, in which inlet and exhaust valves are arranged side by side, and considerable thermal stresses can occur, causing cracking and wear. Similarly, the whole of the piston crown is at an even temperature, and this temperature is kept low by the concentric scavenging action which reaches all round. The engine is therefore largely unaffected by changing load and overload conditions.

As regards the fuel injection system, the intense swirl possible allows much larger holes in the nozzle to be used than with other types of engine. This advantage occurs also in the comet type or pre-combustion head, but there the cooling surfaces are so much larger that the efficiency is lost. It is only necessary to inject the fuel tangentially to the swirl movement to obtain good mixing, and the nozzles can therefore best be arranged near the bottom of the cylinder head, and so do not interfere with the valve passages. Moreover, with the injector set low, the cooling of it is much easier. The larger holes in the nozzles also allow heavier fuels to be used.

It can also be seen that a definite advantage of the telescope valve type lies in the fact that there is only one relatively large central bore in the cylinder head. This allows the whole of the head area to be utilised for valve passages and the channels are correspondingly freed from restriction. Only one inlet duct is needed for the inlet air or charge, through a channel which is preferably spiral shaped to the central inlet bore, and similarly the exhaust gases can be conducted from the central bore right through the inlet valve itself to the outside through one relatively large channel in the head. There are no abrupt changes in the direction or in the through-flow areas or the speeds of the air and exhaust gases.

Results of tests carried out on a single cylinder engine incorporating this valve gear, and having a bore of 110 mm. and a stroke of 145 mm. show that a specific fuel consumption of less than 0·32 lb. per b.h.p. hour, could be achieved at a b.m.e.p. of 130 lb. per sq. in. when it was supercharged by an independently driven charger to 14·2 lb. per sq. in. gauge, the air being cooled to 20 deg. C. before entering the engine. This consumption was maintained with speeds ranging from 1,000 to 1,600 r.p.m. Under the same conditions of super-charge and at 1,600 r.p.m. a power of approximately 29 b.h.p. per litre was achieved. When using an exhaust turbo charger without subsequent cooling of the charging air, the lowest fuel consumption at 1,550 r.p.m. was 0·356 lb. per b.h.p. hour at 95 lb. per sq. in. b.m.e.p. This rose to 0·39 lb. per b.h.p. hour at a maximum b.m.e.p. of 166 lb. per sq. in., under which conditions the temperature before the turbine was 593 deg. C., and at the cylinder exhaust ports 538 deg. C. The charging pressure was 6·9 lb. per sq. in.

Summarising the advantages claimed for this design, they are: its simplicity, both of design and manufacture; the smaller heat losses resulting from the smaller surfaces of the combustion chamber, and resulting in better starting conditions; the possibility of complete scavenging of a four-stroke cycle engine; the ease of fuel injection and the relatively low pressure needed; together with the symmetrical, thermal and mechanical loading of all parts of the cylinder piston and head.

To be continued

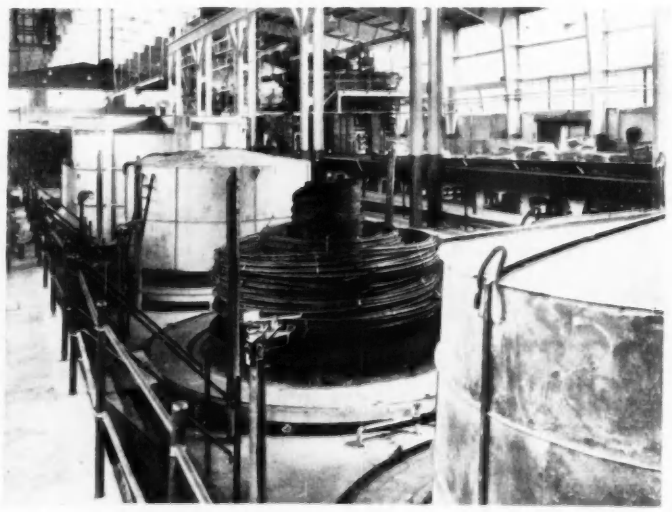
BELL ANNEALING FURNACE

In the article describing the manufacture of mineral-insulated cables, which appeared in ENGINEERING, May 24, page 649, mention was made of the bell annealing furnaces constructed by G.W.B. Furnaces, Limited, Dibdale Works, Dudley, Worcestershire. Further information concerning these furnaces has now come to hand.

Basically, the installation consists of an electrically-heated furnace bell, and a number of circular bases, each base being fitted with means for atmospheric circulation within its gas-tight charge retort. To reduce the weight of the furnace so that it can be handled by a crane, hot face semi-refractory insulating bricks have been used to line the walls and roof. These are backed with a diatomaceous-earth insulating brick, with a final lining of asbestos board against the casing. Heating elements of nickel-chromium strip in sinuous form are arranged round the furnace side walls, the 500 kW rating being divided into three zones on horizontal planes, each zone being fed from an evenly distributed three-phase supply.

The bases are 10 ft. in diameter and 5 ft. high, and are designed to carry coils of cable with a maximum diameter of 10 ft. and a minimum inside diameter of 2 ft. After the bases have been loaded, and the charge retorts lifted in place, the air is purged from them, and replaced by an inert atmosphere. This operation takes approximately two hours, and is carried out before the heating bell is lowered over the base. In the bases are fans, made from nickel-chromium heat-resisting steel, and a sealing trough circumscribes the loading portion in which the knife edged flanges on the inside of the charge retorts fit and are sealed with sand. The protective atmosphere is derived from a G.W.B. burned town's-gas exothermic plant, giving a maximum output of 2,500 cub. ft. of atmosphere per hour. The charge retorts are fabricated from mild steel.

Sets of spring-loaded contacts fitted to the inside of the furnace connect with corresponding sets mounted beside each base; this avoids the use of trailing cables. Temperature control is effected by a three-point Multelec indicating controller.



Mineral-insulated cables are annealed in electric bell furnaces which have an inner sealed retort containing an inert atmosphere.

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STAINLESS STEEL VALVES

Langley Alloys, Limited, Langley, Slough, Buckinghamshire, have announced that owing to improved production facilities they can now offer any of their range of stainless steel valves from stock. The range includes gate, globe and Y-types and lists are being circulated, copies of which may also be obtained on request to the firm.

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NOTICES OF MEETINGS

Building Centre

LONDON
Film: "Zinc in Building," exhibited by the Zinc Development Association. Wed., June 26, 12.45 p.m.

Institution of Electronics

LONDON
"Theoretical Problems of Television Astronomy," by Dr. P. B. Fellgett; and "The 1956 Opposition of Mars," by B. V. Somes-Charlton (with films). Beveridge Hall, Senate House, University of London, W.C.1. Fri., July 5, 6 p.m. (Tickets required.)

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Centenary Celebrations, Tues., June 25, to Thurs., June 27.
Presidential Address by Sir Harold E. Yarrow, Bt.; "A Short Biography of the First President, Professor W. J. Macquorn Rankine," by Professor J. Small; and "Nuclear Power for Ship Propulsion," by Dr. S. L. Smith and Dr. J. E. Richards, at 10 a.m. Various works visits in the afternoon. Banquet in St. Andrew's Halls, Granville-street, Glasgow, at 7 p.m. Tues., June 25.
All-day excursion to the Firth of Clyde, Wed., June 26.
All-day works visits and excursions. Reception by the Lord Provost of Glasgow, in the City Chambers, George-square, Glasgow, at 7.30 p.m. Thurs., June 27.

Physical Society

SOUTHAMPTON
OPTICAL GROUP Summer Meeting, Mon. and Tues., July 8 and 9.
Opening Address, by Professor A. M. Taylor; "Devices for the Measurement of Optica lPhase Differences," by H. G. Jerrard; and "On Spectrophotometric Measurements of Free Radicals Produced Photochemically," by Dr. M. C. K. Symons, at 2 p.m. "The Photoelectric Recording of Interference Fringes," by Dr. E. V. Vernon; "Measurements of the Faraday Magneto-Optical Rotation," by Professor A. M. Taylor; and "Problems of Measuring Phase and Size Simultaneously in a Microscope," by Professor E. Ingelstam, at 4.15 p.m. The University, Southampton. Mon., July 8.
"Artificial Birefringence in Solids," by Dr. J. E. Braybon; "The Theory and Techniques of Micro-Wave Spectroscopy as Compared with Those in the Visible Region," by Dr. J. E. Ingram; "Birefringence in Flowing Liquids," by H. G. Jerrard; and "On Tilton's Vitron Theory of the Structure of Glass," by Dr. W. S. Rodney, at 9.30 a.m. "Precision Measurements of Refractive Index by Means of a Birefringent Shearing Interferometer," by Professor E. Ingelstam, at 2 p.m. The University, Southampton. Tues., July 9.

Plastics Institute

LONDON
Annual General Meeting. Gallery Conference Room, National Hall, Olympia, W.14. Fri., July 19, 12 noon.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Institution of Electronics, 78 Shaw-road, Rochdale, Lancs.
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Plastics Institute, 6 Mandeville-place, London, W.1. (WELbeck 5439.)

In Parliament

SCIENTIFIC INFORMATION SERVICES

Among the debates on the adjournment when the House of Commons rose for the Whitsun recess was one on the need for widely extending Britain's scientific information services, opened by Mr. Frederick Willey (Labour). Britain, he believed, had a brilliant record for scientific research and a brilliant future, but the world was changing at such a pace that this country ought to devote even greater resources, not only to scientific research itself, but to the dissemination of the results of that research to industry. Scientific information must not only be made available as widely as possible, but made available with the greatest possible speed. Only in this way could Britain maintain her superiority in industrial production.

Mr. Willey said that he would confine his remarks to the limited field of the provision of up-to-date current information about scientific research in the form of abstracts, both in the sense of supplying information to research workers to improve and aid their efforts, and in the informative sense of meeting the needs of industry. He realised that there were 127 different publications providing these services from various sources: Government Departments, research associations, professional societies, the larger industrial firms, and the technical journals. He was not in favour of streamlining and unifying research itself, and he welcomed these varied sources of information.

An important publication, *British Abstracts*, had disappeared in 1954, when the Bureau of Abstracts was wound up owing to financial difficulties. Grants-in-aid to the Royal Society for scientific publications had fallen during the past two or three years from £27,000 to £8,500. He was informed that, at present, the *Journal* of the Chemical Society, one of the most highly respected technical journals in the world, was facing very real difficulties. Rising costs were prejudicing both the publication and the content of these valuable technical journals and the work of the abstracting services. He hoped that the Government would review the whole field, especially existing grants-in-aid. These grants should be increased on such a scale as to further encourage abstracting activities.

GETTING THE FACTS QUICKLY

There was much to be said, Mr. Willey considered, for independence and variety in research, and, for this very reason, there was need for a more uniform standardisation of the format in which the results of that work were presented. More frequent indexes were also needed, and duplication should be avoided wherever possible. There were several not unimportant gaps in connection with the publication of abstracts, such as in marine biology, geophysics, and engineering technology, for example. He considered that some form of Government-sponsored agency was called for to co-ordinate and supplement this work.

Another need was for the provision of certain central services; an obvious illustration of which was translation requirements. In this direction, it was interesting to observe the creation by the Soviet Union, in 1953, of the Institution of Scientific and Technical Information Services. That Institution already possessed staffs of several thousand people, produced twelve journals of abstracts and, even more important, provided an express information service. This meant that, in selected fields, the facts could be furnished with the minimum of delay. The desirability of providing a national science lending library and a national science reference library had frequently been urged upon the House.

There was also the need for taking international action in relation to the provision of up-to-date scientific information. He realised that in some respects, in connection with chemical abstracts and medical matters, for example, this country was entirely dependent upon the United States. This help was appreciated, but the mere fact that this country was dependent upon the United States emphasised the need for such information being provided by an international agency.

Finally, there was the urgent requirement that much more should be done to ensure that information was known to, and appreciated by, industry and especially among the smaller firms. The work of Aslib, which had had some 450 people attending its courses during the past three years, was much to be commended. Everything possible should be done to encourage such services and, by publicity, education, and other means, to improve the receptive climate within industry for the acceptance and utilisation of scientific research.

GOOD INDEXES WANTED

Among the points brought out by Mr. Arthur Skeffington (Labour), who spoke next, were the need for more statisticians in Government Departments, for the Government to act as the co-ordinating authority to see that information was readily available, and for the provision of improved indexes to information.

The aim, he thought, should be to provide the sort of index which would give a brief account of major scientific and technical developments in other countries, together with particulars of where the original details regarding these developments could be obtained. Then, an index was wanted which gave brief synopses of developments in various fields, so that people in this country might be kept abreast of what was happening abroad.

Mr. Alfred Robens (Labour) said that Britain could no longer hope to live on the export of textiles, coal, and such-like products. Rather, the nation must depend upon the building of nuclear power stations abroad, the application of electronics to industry, the development of new sciences and the selling of their products abroad, in markets where we had the lead at the moment. To accomplish these things, it was necessary not only to have a large number of technicians in industry, but to support their efforts by a large number of scientists, who, in turn, must be able to obtain the latest information about discoveries in other countries.

FINE WORK BY SPECIALISED RESEARCH BODIES

Replying to the debate, Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, speaking as representative in the House of Commons of the Lord President of the Council, said that, in respect to the exchange of scientific information, as on all other matters, this country desired to move in step with the rest of the Commonwealth. It was as well to remember, therefore, that there existed a standing Commonwealth scientific conference. With respect to Russia, it was true that they had started a centralised scheme and that they had erected a vast building in Moscow, with card indexes, electronic computers and the like. The Russian brand was brand new and started from nothing in 1952-53. It remained to be seen what good could flow from the new Russian efforts.

Britain had had some 40 years' experience in her own special way. The Government thought it best, especially in an activity of this kind, that the different specialist organisations should provide the scientific information services within their own spheres. This way had been found to be a good way, and a way likely to be more effective and more manageable than one single central organisation. It was recognised that certain services needed co-ordinating or supplementing from a central point and it was to that aspect that the Department of Scientific and Industrial Research had devoted much of its energy.

Abstracts were essential to guide scientists to the scientific papers on which they needed to be informed. Many abstracting organisations in this country were facing difficulties owing to the extra volume of scientific literature now being published. Although Britain relied upon the United States service for chemical abstracts, we provided abstracts in physics, and electrical and radio engineering. The Americans used these facilities as much as we used theirs. We were not leaving this field to them.

INFORMING SMALL FIRMS

It was widely recognised, Mr. Nicholls pointed out, that there was very great difficulty in ensuring that scientific and technical information was supplied to small firms in a way that they could understand. The problem was to get the information into the language which they could understand. Small firms must be encouraged to have someone in their organisations who would concentrate on such information and its application.

The United States had experienced the same difficulty, of getting the results of their research into the quarters where the knowledge could be put into practical effect. So far Britain had carried out this work rather better than the Americans, but if they could produce any new ideas which this country could follow, Britain would certainly do so. The small people were not the kind who could be helped by the more elaborate system of scientific abstracts; they needed something much more simple and direct. In particular, the D.S.I.R. was helping the small firms in various ways. An important function of the Department research associations, which were financed partly by industrial organisations, was to ensure that their members obtained in digestible form the research results relevant to them. The Department deserved much credit because it was getting down to the real beginning of things.

Experimental Road Markings

The attention of the House was drawn by Sir James Hutchison, Bt. (Conservative) to the method of facilitating the movement of traffic used in Australia, whereby traffic going up-hill on main roads is allotted, by means of a white line, double the space provided for vehicles descending. Sir James pointed out this procedure allowed the faster traffic to overtake the slower on up-hill journeys, while the faster-moving down-hill traffic was not impeded. He urged the Minister of Transport and Civil Aviation to consider adopting the same system in this country. Mr. Harold Watkinson replied that the procedure referred to was one possible application for the experimental double white line system, if it was eventually decided to make a wider use of that method. The procedure suggested would be unlikely to prove a safety measure, however, unless the lines conveyed a positive prohibition, which motorists could be made to observe rigidly.

Ten Million Vehicles on the Roads

Replying to Mr. John Harvey (Conservative), who asked the Minister of Transport for an estimate of the number of vehicles likely to be using Britain's roads by 1965, Mr. Watkinson stated that a long-range forecast of that kind must necessarily be highly speculative. Judging by the increases in recent years, however, the number of vehicles in use in 1965 might well be of the order of 10 million, which compared with just over 6½ million at the annual census last September.

Redundancy at Ordnance Factories

The question of possible redundancy at Royal Ordnance Factories was raised by Mr. A. W. J. Lewis (Labour). He was informed by Mr. Aubrey Jones, the Minister of Supply, that the Minister had recently held a special meeting of the Joint Industrial Council of the Ministry, at which representatives from all the factories were present. As the delegates were informed, a detailed study was being made of the effect on these factories of the changes in the defence programme and it was intended that a statement should be made as early as possible.

THE HUMAN ELEMENT

Free Trade and Shorter Hours

Hardly is the ink dry on the wage standstill agreement in the engineering industry when the Confederation of Shipbuilding and Engineering Unions lodge a demand for a 40 hour week. If the employers concede the demand, and they are hardly likely to be in the mood to do so at the moment, it will cost the industry rather more than the recent wage settlement.

There can be two views about the reasonableness of this demand. There is much to be said that, when the industry badly needs a period of peace in management-labour relations, a call for a 40 hour week instead of the current 44 hour one is hardly a constructive contribution. By more opportunist standards, however, the move is a shrewd one. The unions have invoked the problems of the Free Trade Area on their side and they are clearly on to a major point. One of the issues which will have to be hammered out in the Free Trade Area proposals is whether the " harmonisation " of wages clauses which have been written into the Treaty of Rome, which establishes (subject to ratification) the European Common Market, are going to be repeated in the F.T.A. Harmonisation includes working conditions and equal pay for women. If there is to be an adjustment of engineering wages and working conditions to meet the requirements of the F.T.A. the sooner the process of adjustment starts the better. But is such an adjustment going to be necessary? Who knows the facts about comparative working conditions here and on the Continent? This is a challenge from within industry to begin to tackle the problems of the Free Trade Area.

Men and Vacancies

There are signs in plenty that brisker business conditions are returning to the economy. One of them is the trend of employment figures. While there is nothing spectacular about them (it would be a reason for some alarm if there were) they are now reflecting the brighter outlook which came with the spring.

According to the latest official returns, the number of notified unfilled vacancies at labour exchanges fell during the month of April and through into the first week of May. There was also a reduction in the amount of short-time working. Unemployment was down, giving an unemployment percentage of 1·5 per cent. in early May compared with 1·6 in April and with 1·1 in May, 1956. From these figures it is clear that there is only a small margin to go before over-full employment is reached. In one respect the trend of the employment figures does not give the full story. It is important not only that workers should be in employment but also that they should be in the right jobs from the point of view of the national economy. The big danger as the unemployment percentage creeps towards 1·0 is that men will start moving out of one kind of job into another and that this will not be reflected in the employment figures. If that should happen, the few gains there have been in the lull in industrial activity by way of switching men into key industries may be undone. It is a state of affairs which will have to be watched.

Faster Haulage

British Road Services have reached agreement with the trade unions about measures to take advantage of the new 30 miles an hour regulations for heavy goods vehicles. The changes are likely to be of widespread interest for there is a certain standard of working conditions operated by the larger hauliers (including C licence holders) which sets something of a pattern for other concerns.

The rise in the speed limit will enable the working day for a driver and his mate to be cut by one hour, with a maximum working day of 10 hours. There is to be no loss of earnings on the present work content, and to meet the changed conditions a bonus payment of 15 per cent. is to be added to basic rates. The use of the word " bonus " is rather unusual for the incentive element in the scheme is obscure unless it is expected that by giving an added 15 per cent. there is less incentive to drag work out so as to earn overtime. Whatever may be the idea the addition is in fact an addition to the basic wage irrespective of output and amounts to a higher time rate.

A number of hauliers and C licence holders have various kinds of incentive schemes based on time saved, ton-miles or lorry capacity—or some combinations of all three. In these cases modification in basic rates and bonus payments may be involved, but there is probably scope for both sides to gain by the adjustment in the speed limit if the issue is handled in a spirit of compromise.

Shipyards Come Into Line

The best feature about the agreement on wages announced last week between the shipbuilding employers and the Confederation is that the wage increase is the same as for the engineering operatives. Had it not been so there would have been a good deal of dispute as to the dividing line between shipyard workers and engineering employees—a matter which could have been a source of friction all round.

The shipyard workers are now committed to a wage standstill at national and district level for a year. This is a move to stop the recent tactics of the boilermakers' union which has held to national agreements but has stimulated wage demands at district level as a means of levering up wages.

One difficult clause has been written into the agreement which is clearly going to mean different things to each side. " Special factors " may upset the wage freeze. This phrase on the employers side will obviously mean some very untoward circumstance, while to the workers it can be taken to mean any set of circumstances which they may not have foreseen. To the more militant in one union in particular, it could no doubt mean that if profits go up quicker than they have done in the recent past, a new demand will be in order. The " strings " accepted by the unions involve discussions this summer about restrictive practices, but no one is committed to anything specific. The whole affair has more the flavour of an armistice than a peace treaty.

Vested Interest in Chaos

Any suggestion to the Trades Union Congress that there is anything other than an aura of sanctity about collective bargaining over wages is like the whiff of gunpowder to an old warhorse. On the Prime Minister's suggestions about a special advisory committee on price stability, productivity and the cost of living, and on the Jack Court of Inquiry's recommendations about a wages court, the T.U.C. has run true to form. It would be surprising if it did otherwise. In a sense, to ask such a body to give quick approval in principle to such an idea is to ask it to help dig its own grave.

At a meeting last week the T.U.C. economic committee considered the Government's proposals and decided that it must ask for further information. Inevitably, when organised labour examines a proposal of this kind it tends to put a great deal more into it than was originally intended or to say that the idea is quite unacceptable. If someone says there should be national oversight of wages, it counters with a suggestion for a similar scheme for company profits.

The fact that profits are already under national scrutiny through taxation is not acceptable to a body which automatically takes up a bargaining position and which must perforce believe that it is more blessed to receive than to give. If they will not accept the idea of national oversight of wages in some form they should at least bring greater pressure to bear on their members to clean up the jungle of varying rates and arrangements which proliferate throughout industry and which are one source of interminable industrial friction.

Ally of Production

Antipathies within companies vary. Sometimes the problem is poor management-labour relations; sometimes it is hostility between sales and production. Not infrequently it is irritation between production and maintenance. In industries where there is a well established tradition of a high capital investment per worker this last is perhaps not very common, but it is met frequently enough where investment policy in a company is passing through an evolutionary process.

A pamphlet issued by the Institute of Industrial Supervisors, *Maintenance and the Supervisor* (price 2*s.* 6*d.*), by Mr. G. C. Cooper, is addressed to this problem. It is a plea for systematic maintenance in which the needs of both the production staff and the maintenance staff are known by either side in advance—emergencies apart. This is a subject which can well be emphasised. Machine loading to an optimum level and proper quality control are not possible over a period of time without it. Both these are key matters for British industry as it faces increasing mechanisation and the need to increase its exports.

In no other way can accurate production planning on reliable machines be achieved. It should be added, however, that an attitude of mutual respect and co-operation by both departments must be encouraged higher up. In most companies where machines are " flogged " the attitude is developed at the top, and it is at the top where the educational process must start in cases where the problem exists.

Hot and Sticky

A paper on " Method Study of Hot Working Conditions " by Mr. J. A. C. Williams has been issued by the College of Aeronautics at Cranfield. The text is written mainly for work-study engineers and its jargon, as in all method study and time and motion study, makes it difficult for the layman to follow it without some passing knowledge of the terminology.

The paper presents a system of study for hot working conditions (not to be confused with hot-working conditions though there is some overlap between the two). It advocates the establishment of heat stress indices using measurable quantities in terms of temperature and air-speed. Although the system can be used for the establishment of fatigue allowances in time and motion study the author prefers to see it at this stage as an aid to method study. The development of this kind of work will be followed with interest, however, as an alternative to the usual conventional techniques used for establishing fatigue allowances where there are hot working conditions.

The more checks there are on fatigue in time study the better, for there are few more fruitful sources of argument in installing incentive schemes.